

Professional Development for Prospective Epidemiology Teachers in Grades 6–12

MARK A. KAELIN, EdD^a
WENDY W. HUEBNER, PhD^a
RALPH L. CORDELL, PhD^b
BRIAN SZKLARCZUK, MPA^c

“I have to think about why anyone would want to remember particular pieces of information. What does this fact help you understand? What problems does it help you address?”

—As quoted in Ken Bain’s *What the Best College Teachers Do*, 2004¹

How old were you when you heard the word *epidemiology* for the first time? At what stage in your career did you take your first epidemiology course? What events and decisions had to align for these events to occur? Did that alignment occur because of a well-conceived plan or was it more or less by serendipity?

Many, if not most, answers to these questions from members of the public health community will include “graduate school” and/or “serendipity.” As the size of the public health workforce dwindles and its responsibilities increase, it is time to ensure that the answers future cohorts give to these questions will include “middle and high school” and “a well-conceived plan.”

Younger students can learn epidemiology and understand its role in public health. The inductive and deductive reasoning of epidemiologic sleuthing captures students’ curiosity. The limitations of epidemiologic study designs and the making of causal judgments when evidence is missing and/or flawed can challenge the critical-thinking skills of the best of students. Designing public health strategies based on such evidence can stir even the most laid-back student’s sense of right and wrong. And all of this engagement is heightened when the issues being explored are of immediate relevance, whether it be backpacks and back pain, watching television and being overweight, or sleep deprivation and academic performance. If students have these experiences when the career-path playing field is still level, it seems likely that more of them will consider careers in public health.

More importantly, perhaps, is the benefit to the majority of these students, whether or not they opt for public health careers. Knowledge of epidemiology arguably will prepare students to become more scientifically literate personal

^aCollege of Education and Human Services, Montclair State University, Montclair, NJ

^bCenters for Disease Control and Prevention, Atlanta, GA

^cPublic Health Agency of Canada, National Microbiology Laboratory, Winnipeg, MB

Address correspondence to: Mark A. Kaelin, EdD, College of Education and Human Services, Montclair State University, University Hall-4201, 1 Normal Ave., Montclair, NJ 07043; tel. 973-655-7123; fax 973-655-4337; e-mail <kaelinm@mail.montclair.edu>.

and public health decision makers, who will be able to appreciate epidemiologic evidence and provide support for public health initiatives. While epidemiology can be viewed as a required core course for public health professionals, it has more than simply vocational value. Even if public health workforce issues were no longer a problem, there would still be a legitimate scientific literacy argument for infusing epidemiology education into the curricula of grades 6–12. Are biology, chemistry, and physics taught for merely vocational purposes?

This article begins to address what will be a necessary, but not sufficient, component of a well-conceived plan—deciding what sort of professional development experiences need to be created to prepare middle school and high school teachers to teach epidemiology, a science about which few have had previous knowledge. What epidemiologic knowledge is needed to teach epidemiology effectively? How can teachers be prepared to teach this science?

To begin to plan the professional development experiences that prospective grade 6–12 epidemiology teachers would need, we might take a few epidemiology textbooks off our shelves and, paying particular attention to the tables of contents, begin to create a list of topics. We might recall some favorite epidemiology lessons we experienced as students. We might start to create a collection of assigned readings such as a textbook, a combination of historical epidemiology-related documents, some dramatic case studies, and some current newspaper columns. For a change of pace, we might think of a video and a guest speaker or two. In short, we might begin to plan this professional development by thinking about what we, as providers of professional development, will do. We might plan this professional development as a series of activities during which we cover an assortment of epidemiologic topics that are sure to engage budding teachers of epidemiology.

All of this may be of value, but the National Research Council (NRC) warns that learners “. . . presented with vast amounts of content knowledge that is not organized into meaningful patterns are likely to forget what they have learned and to be unable to apply the knowledge to new problems or unfamiliar contexts.”² Needless to say, a new teacher of epidemiology does not want to be in this situation when a student asks a question. The NRC concludes, “Learning with understanding is facilitated when new and existing knowledge is structured around the major concepts and principles of a discipline.”²

FUNDAMENTAL UNDERSTANDINGS AND BACKWARD DESIGN

Grant Wiggins and Jay McTighe, authors of *Understanding by Design*, call the major concepts and principles of a discipline “enduring understandings” and argue that the foundation for creating effective professional development experiences lies in the identification of these “big ideas that reside at the heart of a discipline and have lasting value outside the classroom.”³ They also suggest that answering the question about what we, the providers of the professional development, will do, is the last stage in a three-stage process they call “backward design.”³ They suggest that we begin to design our professional development experiences not by identifying what *we* will do, but by identifying the big ideas, enduring understandings, and major concepts and principles of the discipline we want our learners to understand.

What are epidemiology’s fundamental understandings? What are the epidemiologic concepts and principles around which budding epidemiology teachers can structure their burgeoning epidemiologic knowledge? To gain consensus on a list of epidemiology’s major understandings, two of the authors of this article polled judges for the Robert Wood Johnson Foundation (RWJF) and College Board’s Young Epidemiology Scholars Competition, using a four-round, electronic, consensus-building process, over a period of eight weeks.⁴ The 26 invited judges included 12 epidemiologists and one high school statistics teacher, all of whom participated in our poll. By the end of the fourth round, 12 concepts and principles had scores of 3.5 or higher (equivalent to a response of “definitely yes” or “probably yes”) on a five-point Likert scale (unpublished data).

To make these understandings helpful to prospective epidemiology teachers, we attempted to remove epidemiology-specific vocabulary and incorporated familiar language when possible. At the same time, we tried to retain sufficient nuance to help teachers realize that the development of these understandings can be empowering for them and their students. We also arranged the 12 concepts and principles in the following logical sequence:

Fundamental epidemiologic understandings

1. The causes of health and disease are discoverable by systematically and rigorously identifying their patterns in populations, formulating causal hypotheses, and testing those hypotheses by comparing groups. These methods lie at the

- core of the science of epidemiology. Epidemiology is the basic science of public health, a discipline responsible for improving health and preventing disease in populations. (This is an overarching understanding for epidemiology.)
2. Health and disease are not distributed haphazardly in a population. There are patterns to their occurrences. These patterns can be identified through the surveillance of a population.
 3. Analysis of these patterns can help formulate hypotheses about the possible causes of health and disease.
 4. A hypothesis can be tested by comparing the frequency of disease in selected groups of people with and without an exposure to determine if the exposure and the disease are associated.
 5. When an exposure is hypothesized to have a beneficial effect, studies can be designed in which a group of people is intentionally exposed to the hypothesized cause and compared to a group that is not exposed.
 6. When an exposure is hypothesized to have a detrimental effect, it is not ethical to intentionally expose a group of people to the hypothesized cause. In these circumstances, studies can be designed that observe groups of free-living people with and without the exposure.
 7. One possible explanation for finding an association is that the exposure causes the outcome. Because studies are complicated by factors not controlled by the observer, other explanations also must be considered, including chance, confounding, and bias.
 8. Judgments about whether an exposure causes a disease are developed by examining a body of epidemiologic evidence as well as evidence from other scientific disciplines.
 9. While a given exposure may be necessary to cause an outcome, the presence of a single factor is seldom sufficient. Most outcomes are caused by a combination of exposures that may include genetic makeup; behaviors; social, economic, and cultural factors; and the environment.
 10. Individual and societal health-related decisions to improve health and prevent disease are based on more than scientific evidence. Social, economic, ethical, environmental, cultural, and political factors may also be considered in decision-making.
 11. The effectiveness of a health-related strategy can be evaluated by comparing the frequency of disease in selected groups of people who were and were not exposed to the strategy. Costs, trade-offs, and alternative solutions must also be considered in evaluating the strategy.
 12. An understanding of phenomena unrelated to health can be developed through epidemiologic thinking, by identifying their patterns in populations, formulating causal hypotheses, and testing those hypotheses by making group comparisons.
- Each of these understandings can be thought of as a file drawer into which teachers, and later their students, can structure and organize their developing epidemiologic knowledge. This allows the teacher to view this knowledge not as a disconnected assortment of facts, but as a component of an underlying organizational structure—knowledge that “. . . is connected and organized, and . . . ‘conditionalized’ to specify the context in which it is applicable.”²
- Wiggins and McTighe suggest filters through which subject matter must pass to be considered an enduring understanding. The subject matter must do the following:
- Represent a big idea having lasting value outside the classroom
 - Reside at the heart of the discipline and involve “doing” the subject
 - Require the uncovering of abstract or misunderstood ideas³
- Let’s consider the second and third of our proposed fundamental epidemiologic understandings:
- Health and disease are not distributed haphazardly in a population. There are patterns to their occurrences. These patterns can be identified through the surveillance of a population.
 - Analysis of these patterns can help formulate hypotheses about the possible causes of health and disease.
- Do these two concepts pass through the filters Wiggins and McTighe presented? Does their development provide new epidemiology teachers with knowledge to empower them to comprehend not only the world they presently live in, but also the world in which they will live? Are these understandings cornerstones of epidemiology, population thinking, and the idea that when confronted with a single instance of something, one can learn more about it by viewing it in the context of a population? These two concepts do pass through

these filters because when teachers develop these understandings, they will uncover abstract and misunderstood ideas; the value of a precise case definition; ways of expressing the number of cases; the challenge of identifying an appropriate denominator; the need to adjust rates; the ways disease patterns can be described in terms of person, place, and time; and the mechanisms used in existing surveillance systems.

Jerome Bruner, in *The Process of Education*, also emphasizes the value of identifying a content area's big ideas: "To understand something as a specific instance of a more general case . . . is to have learned not only a specific thing, but also a model for understanding other things like it that one may encounter."⁵ In our professional development programs, there is little question that whatever "specific instance" or "specific thing" we choose to focus on to develop the fundamental understandings, teachers will encounter other things like it. As an example, consider human immunodeficiency virus/acquired immunodeficiency syndrome as a specific instance and explore it in terms of the proposed fundamental understandings. Would the same big ideas provide future epidemiology teachers with a model for understanding similar health and disease issues such as severe acute respiratory syndrome, West Nile virus, carpal tunnel syndrome, or Gulf War syndrome? By designing professional development experiences around fundamental understandings, we empower learners to understand not just today's instances but tomorrow's—"to see past the surface features of any problem to the deeper, more fundamental principles of the discipline."²

FROM FUNDAMENTAL UNDERSTANDINGS TO AUTHENTIC ASSESSMENT

With these understandings as a foundation, Wiggins and McTighe advocate that we now think like assessors and determine what acceptable evidence of the mastery of those understandings would look like. How will we know if the teachers attending our professional development workshops grasp these understandings? How can we design professional development experiences for future epidemiology teachers that will make their understanding observable?⁶

One way to make an understanding observable is to create assessments, in an authentic setting, for which an understanding of a big epidemiologic idea is essential. Such assessments require future epidemiology teachers to do more than recall specific knowledge and demonstrate specific skills; they require learners to select what knowledge and skills will allow them

to answer a particular question in a particular set of circumstances.

For future epidemiology teachers in grades 6–12, authentic experiences will center on what occurs in their classrooms and how they prepare for and respond to those experiences. This is the way teachers' knowledge of epidemiology will be tested in their real world. Therefore, from a professional development perspective, our assessments of their understanding should be as authentic as possible. Realistic circumstances are readily available in a typical professional development workshop by having teachers create and teach epidemiology lessons to other workshop participants that address particular understandings. These circumstances are realistic; they require judgment and innovation; they require more than simply recalling facts; they replicate the context in which the teachers will be tested in the classroom; and they allow opportunities for rehearsal, practice, consultation, feedback, and refinement.

A PORTFOLIO OF EPIDEMIOLOGY EDUCATION MATERIALS

Fortunately, prospective sixth- through 12th-grade epidemiology teachers do not need to start with a blank sheet of paper when creating their epidemiology lessons. Over the past five to 10 years, a growing portfolio of epidemiology education materials has been developed. Although these materials were developed with particular age groups in mind, the authors' experience has been that lessons developed for one age group can often be adapted for another. Four examples follow.

1. The Public Health Agency of Canada (PHAC) National Microbiology Laboratory in Winnipeg, Manitoba, has created *Buffet Busters*, a resource developed to promote infectious disease awareness and introduce concepts related to foodborne and waterborne infectious diseases, using basic principles of epidemiology. It was developed as a collaborative effort with representatives from the Centers for Disease Control and Prevention (CDC) and is targeted to students in grades 6–11 (available from: URL: <http://www.nml-lnm.gc.ca>).⁷
2. The College of Education and Human Services, Montclair State University in Montclair, New Jersey, has created an epidemiology curriculum called *Detectives in the Classroom* for middle and high schools (grades 6–12). The curriculum is aligned with national science,

mathematics, and health standards. It consists of 34 investigations organized into five modules, each constructed to teach students fundamental epidemiologic understandings that address descriptive epidemiology, analytic epidemiology, association and causation, prevention strategies, and strategy evaluation (available from: URL: <http://www.montclair.edu/detectives/index.shtml>).⁸

3. CDC has created Excellence in Curriculum Integration through Teaching Epidemiology and the Science of Public Health (EXCITE) for teachers in grades 6–12. EXCITE provides teachers with case studies that present students with real public health problems and, by asking thoughtfully sequenced questions, guide learners through epidemiologic investigations of the problems. Each of the case studies can be taught independently from the other case studies, giving teachers the flexibility to insert an epidemiologic lesson into their teaching schedules as time permits (available from: URL: <http://www.cdc.gov/excite/index.htm>).⁹
4. RWJF has created a Young Epidemiology Scholars (YES) curriculum for high school teachers (grades 9–12). The curriculum provides teachers with 25 YES Teaching Units. These units are designed to stand alone, giving teachers the flexibility to insert an epidemiologic unit into their teaching schedules as need and time permit. In addition, these units are categorized by discipline (biology, social science, mathematics, environmental science, health education, statistics, English, and chemistry), encouraging teachers of a variety of disciplines to infuse the science of epidemiology into their classes (available from: URL: <http://www.collegeboard.com/yes/ft/iu/home.html>).¹⁰

At first glance, this assortment of lessons—created by different organizations, based on different pedagogical principles, and with a variety of age groups in mind—may appear to be a disconnected assortment of information. However, if we as providers of professional development have categorized these lessons into a file cabinet of fundamental epidemiologic understandings, as described previously, it will allow teachers to view these lessons not as a disconnected assortment of facts, but as a means of teaching a component of an underlying organizational structure that they can connect, organize, and conditionalize for use in their classrooms.²

As an example, let's return again to the second

and third fundamental epidemiologic understandings referred to previously:

- Health and disease are not distributed haphazardly in a population. There are patterns to their occurrences. These patterns can be identified through the surveillance of a population.
- Analysis of these patterns can help formulate hypotheses about the possible causes of health and disease.

The PHAC's Buffet Busters addresses these understandings through an interactive classroom activity that serves as an introduction to infectious diseases and the human impacts of disease. Students work through a series of case studies that build in complexity and difficulty, in which they are tasked with observing, formulating hypotheses, and identifying the cause and source of an infectious disease outbreak. It is a flexible activity that can be adapted to any classroom setting, ranging from one to four hours of classroom time. In addition to the classroom activity, an interactive Web-based game provides an opportunity to expand their skills and abilities through four complex scenarios. The activity was designed as a model that can be delivered by high school students, who can serve as effective role models for science awareness (available from: URL: <http://www.bufferbusters.ca>).¹¹

Montclair State University's Detectives in the Classroom addresses these understandings with several investigations, including "What's My Hypothesis?" In this lesson, each student is assigned an exposure and, while assuming that the exposure causes a disease, is asked to write a description of how a hypothetical disease would be distributed in terms of person, place, and time. Students then review one another's descriptions and formulate one or more hypotheses for each. When students compare their hypotheses, they realize that a given person, place, and time distribution of a health-related outcome can lead to the formulation of a number of different educated guesses (available from: URL: <http://www.montclair.edu/detectives/curriculum/Investigation1-3.htm>).¹²

CDC's EXCITE website features a series of student exercises based on its description of "How to Investigate an Outbreak." Students learn about the 10 steps in an investigation, using examples in the lessons. Step 5 is to describe and orient the data on cases in terms of person, place, and time (available from: URL: <http://www.cdc.gov/excite/classroom/outbreak/steps.htm#step5>).¹³ In addition, "Suspected Legionnaires' Disease in Bogalusa," another of the EXCITE case studies, addresses this understanding by showing how epidemiologists weigh evidence from multiple patterns

to identify the most likely cause of an illness (available from: URL: <http://www.cdc.gov/excite/classroom/legionnairesQ.htm>).¹⁴

Finally, RWJF's YES Teaching Units address these understandings with several units, including "Casualties of War," in which a teacher leads students through an analysis of the patterns of short- and long-term health effects of the 1945 atomic bomb attacks on the Japanese population. It concludes with present-day attempts to do a similar analysis, using today's epidemiologic skills to identify the patterns of short- and long-term health effects of 9/11 (available from: URL: http://www.collegeboard.com/yes/ft/iu/casualties_of_war.html).¹⁵

By having prospective epidemiology teachers use existing lessons as a starting point, these websites help teachers develop their own grasp of the fundamental understandings. In preparing to teach, they will select and adapt portions of a lesson that they believe will be valuable to their workshop peers and anticipate what their learners already know, as well as their misconceptions and questions. In teaching the lesson, they will orchestrate a logical sequence of events in a manner that keeps their learners' attention and will spontaneously adjust their plans as the need arises. And after teaching the lesson in the workshop setting, they will reflect on their experience and decide whether they helped the other workshop participants—their first epidemiology class—develop the fundamental epidemiologic understandings.

All of this authentic preparing, teaching, and reflecting will take on additional value if we have created in our professional development workshops what the NRC calls ". . . a professional community that discusses new teacher materials and strategies and that supports the risk-taking and struggle entailed in transforming practice."²

WHERE DO WE GO FROM HERE?

Based on the 12 fundamental epidemiologic understandings and the authentic assessments we have created for workshop participants, we are now ready to decide what we, as providers of professional development, will do. We can consider the understandings and their assessments as a rubric for determining what we will do and, by extension, what we will not do during professional development workshops. We only will do what will enable future epidemiology teachers to develop the fundamental epidemiologic understandings and create evidence of such. We will be enablers.

Let's return to those epidemiology textbooks we took

off our shelves, those favorite epidemiology lessons we experienced as students, that list of assigned readings, and those videos and guest speakers we identified. Do we discard those plans? Not necessarily. We apply our understanding/assessment rubric to these plans. And, given the time frames for our professional experiences, we implement the parts of the plan that will enable budding epidemiology teachers to develop the understandings and demonstrate them in authentic circumstances—their classrooms.

Wiggins and McTighe suggest that a discipline's fundamental understandings are unlikely to be understood if merely taught, and they advise, "To be fully understood, it [an enduring understanding] will have to be explored, questioned, played with, used in realistic contexts, rephrased, and verified as important in some way," or what they refer to as "meaning making work."³

This is what we can do in our professional development workshops. We can create enabling, "meaning making work" experiences, aligned with epidemiology's fundamental understandings, that empower teachers to teach the science of public health.

The suggestions in this article for the professional development of teachers of epidemiology in grades 6–12 are made to provide public health educators with a paradigm to consider. But professional development experiences built on this or other paradigms will need to be evaluated to determine if participation in such workshops increases teachers' knowledge of epidemiology, interest in teaching epidemiology, perceived competence to teach epidemiology, commitment to teaching epidemiology, and actual teaching of epidemiology.

We can begin this evaluation by simply comparing pre- and post-professional development workshop assessments to evaluate the degree to which they achieve the desired teacher outcomes stated previously. More rigorous testing may be feasible by comparing workshop participants to nonparticipants, and perhaps by further testing of one professional development paradigm vs. another. While such assessments would measure impacts of the workshops on teachers, we recognize that the ultimate questions are about the sixth- to 12th-grade students. We want to learn whether the students who are taught by these teachers are becoming more scientifically literate and whether greater numbers of them later choose public health career paths. However challenging this may be to directly measure, we assert that effective professional development is a necessary component of a well-conceived plan for infusing epidemiology education into grades 6–12 curricula.

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The authors consider the identification and phrasing of the Fundamental Epidemiologic Understandings as iterative—a work in progress. If you would like to suggest additions and revisions, you can do so by linking to <http://www.montclair.edu/YESteachingunits/EndEpUnd.html>, where they are referred to as “Enduring Epidemiologic Understandings,” and selecting “Additions and Revisions” from the menu.

For more information about this and other components of a plan to infuse epidemiology education into grades 6–12 curricula, see the Epidemiology Education Movement's concept map, available from: URL: <http://www.epiedmovement.org/conceptmap.html>.

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