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On Linkages

ACCESS TO HEALTHY FOOD IN A LOW-INCOME URBAN COMMUNITY: A SERVICE-LEARNING EXPERIENCE

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Service learning is difficult to define due to the wide spectrum of programming to which this term is applied. Programs range from one-shot efforts to courses that are fully integrated into a school's curriculum. Eyler and Giles assert that service learning should include a balance between service to the community and academic learning.[1] Reflection on the process of engaging with the community remains central to the value of service learning.

Service learning provides an opportunity for students to develop critical-thinking skills, gain contextual understanding of complex issues, engage in thoughtful decision-making, apply theory to practice, develop independence and leadership, and maximize the learning process through the exchange of ideas with others. Knowlton and Sharp extol these advantages, and quote Gagne:

> Through this type of research and analysis, students become more adept at managing the ambiguity and volatility inherent in real-world scenarios. In fact, (this) method reinforces a "central point of education—to teach people to think, to use their rational powers, to become better problem solvers."[2,3]

Service learning provides extraordinary benefits for the student over traditional methods of instruction. Students take personal responsibility for learning in the present and develop skills for becoming active learners. Students develop skills through acquiring and critically evaluating new knowledge, as well as gain proficiency in reasoning. In addition, students further develop interpersonal skills, particularly with respect to giving and receiving constructive criticism and gaining a commitment to self and group improvement.[4]

The students' community partners will benefit from a successful service-learning partnership by acquiring information and/or resources needed to fulfill a social change mission associated with society's most complex problems such as poverty, homelessness, and hunger. Typically, community partners have few resources and limited opportunities to effectively influence structural change in the community context. Agencies are often charged with collecting quantitative data that demonstrate outcomes, as well as implementing best practices for their programs. Service-learning partnerships can facilitate these efforts for those who are dedicated to improving the quality of life for disadvantaged people.[5]

The purpose of this article is to describe a graduate-level public health service-learning course based on the following community issue: access to healthy food in a low-income urban area. Course expectations required students to interact with practitioners and community members while conducting research. In addition to the course description and community issue, this article presents data collection methods, results, and students' reflections on the project.

COURSE DESCRIPTION

The graduate-level course, entitled Public Health in Action and offered by the College of Public Health, Ohio State University, in Columbus, Ohio, is designed to offer students an opportunity to benefit from a service-learning experience. Public health practice occurs in a social context and is subject to all the complexities of a social environment. Therefore, this type of experiential learning provides future practitioners with a rich opportunity to bridge theory and practice while encouraging reflection and decision-making. Students were expected to fully participate in the team learning experience with practitioners and other students; engage in assessment activities as defined by the community partner; collect, analyze, and synthesize data; prepare and present a final report to community

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partner staff; and prepare and present reflections on the service-learning method and group process.

Columbus Public Health in Columbus, Ohio, served as the community partner for this project. Columbus Public Health's Division of Planning and Preparedness is charged with providing leadership to engage communities and other health-care agencies in developing community action plans for health improvement in medically underserved neighborhoods. The assumptions underlying this effort are that successful health improvement initiatives require community involvement and the understanding that specific communities have unique needs.

COMMUNITY DESCRIPTION

The community in which this project took place is on the west side of Columbus, located close to the downtown area, and is the oldest community in central Ohio. It is also the poorest neighborhood in Columbus, with a median household income of less than $17,000 (30.0% of households earn less than $10,000). The majority of the population is white (75.5%) with 25.7% of the residents classified as part of a minority group. This area has the highest number of residents in the city who do not have a high school diploma. Only 21.0% of the residents own their own home, and one-fifth of the housing structures are vacant.[6]

COMMUNITY ISSUE

The student project focused on access to and cost of healthy food in this underserved, urban area. Research indicates that location, nutrition, cost, culture, weight control, taste, and convenience are factors that influence dietary and lifestyle choices. The physical availability of healthy foods is particularly important when considering socioeconomic status and race. Morland et al. report in their study of several census tracks that supermarkets were four times as likely to be in predominantly white neighborhoods and that the small corner grocery store is most likely to be located in the predominantly African American, poor neighborhood.[7] The lack of availability of healthy food in small grocery stores located in low-income neighborhoods and the higher cost of the healthier food items may be a deterrent to eating healthier among very low-income consumers. Algert et al. note that access to supermarkets and other stores offering fresh produce and other healthy foods is often different between impoverished and wealthier neighborhoods. These researchers conclude that providing access to low-cost fresh produce and foods in low-income neighborhoods could substantially reduce the risk of chronic illness and other health-related complications.[8]

METHODS

Students enrolled in Public Health in Action met with the health planner of Columbus Public Health and were introduced to "Improving Access to Healthy Food: A Community Planning Tool."[9] This document was designed to enable community residents to find ways to bring healthier foods into their neighborhoods by implementing one or more food access strategies. These strategies included working with corner grocery stores, working with existing supermarkets, bringing new supermarkets to a neighborhood, food cooperatives, buying clubs, food kiosks, farmers' markets, and community gardens.

Students were expected to conduct an environmental scan of the designated area, noting community assets as defined by Kretzmann and McKnight as well as community deficits.[10] Students also conducted visual food item surveys of the 12 food stores located in the designated area, based on recommended healthy food items from the U.S. Department of Agriculture and its Women, Infants, and Children Program. The students recorded the availability and quantity of healthy food, product placement, access to public transportation, and general environmental conditions. None of the food stores were associated with major grocery chains. Key community informants—including citizens, community leaders, and city personnel working out of the Neighborhood Pride Center—were interviewed regarding their perceptions about access to healthy food and about residents' eating and food purchasing habits, as well as their opinions regarding the feasibility of the healthy food access strategies outlined in "Improving Access to Healthy Food: A Community Planning Tool." The class also visited the food pantry that served this area.

RESULTS

Students noted a number of assets. This community is located in close proximity to downtown, providing access to major thoroughfares and bus routes. A library, community center, parks, schools, and churches are also found in the area. Services are abundant and include child care, summer programs, food pantries, clothing and household goods, free clinics, and government housing. However, many of the key informants felt that community assets were underutilized.

Community residents also experience a variety of barriers. Many residents do not have personal

transportation and must rely on friends and family, buses, or taxis to purchase groceries. All of the large supermarkets in the area are closed, so many residents rely on the corner stores, which typically lack fresh produce. The corner stores stock and advertise snack foods, alcohol, cigarettes, and lottery tickets. Owners of these businesses often do not live in the area and therefore are perceived as not invested in the health of community residents. In addition, community streets are lined with fast food establishments.

Key informants identified generational poverty as a major issue. Informants also surmised that many residents may not understand the correlation between eating habits and current and future health issues. Key informants almost universally rejected the strategies outlined in "Improving Access to Healthy Food: A Community Planning Tool." The strategies rely on community readiness, which was described as unlikely in this area at this time.

One informant indicated that some residents had to choose between food and "a roof over their heads." Healthy food is often considered expensive and difficult to prepare, making fast food a more attractive alternative. Nonworking appliances and insect infestation become formidable barriers to healthy food storage and preparation as well.

Students surveyed 12 food stores in the area and found that the smaller the establishment, the less likely that fresh produce was available for sale. The majority of stores carried canned fruits and vegetables, and breads and grains. Prices were universally lower at the larger stores. The cost of a loaf of white bread ranged from $0.79 to $2.79; milk from $1.99 to $3.59 a gallon; and a dozen eggs from $0.69 to $1.59. In many locations, students noted dairy products such as yogurt and cheese for sale that were a month past their expiration dates. Alcohol was sold at every location and typically placed in the front of the store. Store windows were often covered with alcohol and cigarette advertisements and lottery signs.

Findings were consistent with research previously conducted in low-income, urban areas. The high cost and limited availability of healthy food, along with other identified barriers, increase the difficulty of consuming a nutritious diet.

RECOMMENDATIONS

Like many other low-income, urban neighborhoods, this Columbus community has seen better times. In recent years, all major supermarkets in the area have closed, leaving the small corner store as the only option for residents without transportation. These stores offer a small inventory of healthy food choices, promote alcohol and tobacco products, and are often sites for illegal drug trade. Small markets and corner store operators are not interested in and see no cost benefit to offering more healthy food options in their establishments. Although key informants generally expressed a desire for a supermarket in the area, the students felt that research into why the big chains pulled out should precede any effort to recruit a new one into the area.

Key informants expressed doubt as to whether any of the strategies outlined in "Improving Access to Healthy Food: A Community Planning Tool" would be successful, as many had been tried before but not sustained. However, churches and schools were mentioned as trusted institutions that could be utilized as vehicles for community education.

Behavior change is unlikely without attention to some of the environmental constraints such as lack of transportation, pest infestation, unsafe neighborhoods, and a high concentration of alcohol outlets. Policy changes that address some of these issues might have a positive impact.

In sum, students felt that community planners should proceed carefully when addressing the issue of availability of and access to healthy food. Government intervention is viewed with distrust, and many efforts designed to improve the area have not been sustained or have failed. Instead of attempting one of the strategies from the "Community Planning Tool," existing trusted institutions such as churches and schools should be mobilized to influence food purchasing, preparation, and consumption behaviors. Attention to environmental barriers should be considered as well. Research into efforts that have been successfully implemented in demographically similar communities might offer insight into how best to proceed.

LESSONS LEARNED

Practical experience intertwined with classroom learning offers a new perspective to students and allows them an opportunity to apply classroom knowledge. The field of public health is based on a social justice philosophy. Many public health problems disproportionately affect some groups. This course exposed the students, most of whom had limited personal experience with diverse neighborhoods, to the disparity in the availability of healthy food in an underserved area. These students' comments included the following:

> My experience in class has given me insight into how difficult public health actually is. In class, we always have the right answers, always have the ideas that will

> "work," and I've always pictured myself educating people about how to be healthy with the result that all of a sudden they will be. This class sort of shattered those thoughts for me.
>
> It made me think, and gave me the chance to look at the bigger picture, instead of assuming we have all the answers.
>
> I know that I have developed a new way of looking at societal problems, and I will carry these lessons with me into the future.

Student course evaluations revealed a high level of satisfaction with this experience, especially regarding the community engagement aspect and the opportunity to work with a local health department. However, many students became invested in the community and expressed concern that the assessment and recommendations would not be acted upon:

> I have a fear in the pit of my stomach that the information we came up with may be presented, filed away, and never developed into something that could truly help the community.
>
> I really hope to see this project go somewhere after the information is presented. I wish as a graduate student I could devote more time to the issue after being involved and observing a community that I never knew too much about. There's a big part of my heart that goes out to the people.

Although the focus of a course such as the one described in this article will change according to the issue and the partners, faculty attempting to engage students in community-based research would be well advised to consider some general issues in advance. Some measure of control is sacrificed when the community becomes the classroom. Partnering with the community should be viewed as a process as opposed to a discrete event. Faculty would benefit from recognizing that all parties bring liabilities and assets, and from acknowledging the complexity of social organizations. To reduce sources of tension, roles and responsibilities of all participants and the final product should be agreed upon prior to course initiation. Finally, students should be advised to recognize political realities that may impede their ability "to get the job done."

CONCLUSION

Service learning encourages what Eyler and Giles refer to as a "connected view of learning," allowing the student to link personal and interpersonal development with academic and cognitive development.[1] The student learns the subject matter while engaged in the process of acting and reflecting, thereby "learning to be effective while learning what to be effective about."[11] When reflecting in their journals and final papers, all of the students noted that what they learned and observed could be combined with their skills to impact a public health issue.

Although this article describes one class with a small number of students, this method of teaching and learning is promising. Community-based, service-learning research is an underutilized form of scholarship that has the potential to prepare students to become active and committed citizens and practitioners in our diverse society.

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On Academics

TEACHING RESEARCH METHODS TO GRADUATE STUDENTS IN PUBLIC HEALTH

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In *The Future of Public Health*, the Institute of Medicine (IOM) recommended improved instruction in quantitative methods and research skills in public health.[1] The IOM emphasized the ethical commitment of public health professionals to use quantitative knowledge to reduce suffering and enhance quality of life. A Harvard study found that two-thirds of the alumni ranked quantitative skills as directly applicable to their profession, supporting IOM's position.[2] The IOM report recognized inadequate education and training of the workforce as one of the causes of disarray.[1]

The Public Health Faculty/Agency Forum addressed the educational dimensions of IOM's findings, and core competencies were developed for Master of Public Health (MPH) students.[3] Embedded in these competencies were specific objectives: the ability to (*1*) define, assess, and understand factors that lead to health promotion and disease prevention, (*2*) understand research designs and methods, (*3*) make inferences based on data, (*4*) collect and summarize data, (*5*) develop methods to evaluate programs, (*6*) evaluate the integrity of data, and (*7*) present scientific information to professional and lay audiences. The Forum also suggested that faculty review, evaluate, and refine established courses and develop new ones. However, the Forum did not outline teaching strategies to achieve these objectives.[4] Employing improved teaching methods implies stronger evaluations of existing classes from which stronger teaching methods may be derived.

Two methods of instruction have been empirically validated: Keller's Personalized System of Instruction (PSI)[5] and Socratic-Type Programming.[5,6] Keller emphasized the following components: (*1*) identification of specific terminal skills or knowledge, (*2*) individualized instruction, (*3*) use of teaching assistants, and (*4*) use of lectures as a way to motivate students, not just to transmit information. PSI has been more effective than conventional instruction in a variety of educational settings and has increased student achievement and consumer satisfaction more than conventional instruction.[7,8]

Socratic-Type instruction emphasizes student responses during lecture, rather than presentations by instructors.[6,9,10] PSI calls for active responding in the classroom and the Socratic Method is one means of achieving this response. Moran and Malott summarize the empirical evidence and most reliable teaching technologies to date, from which it is clear that frequent quizzing coupled with Socratic procedures contributes importantly to learning.[11] A recent study of active learning assessed the use of study guide questions for pending lectures, and outcomes were greater for the study guide than for traditional lecturing.[12]

Research methods should be taught and evaluated by the very methods being taught. This requires experimental or quasi-experimental methods to model the application of science for teaching evaluations. Connelly and associates called for the development of reliable and valid measurement of specified competencies in public health education.[13] Sarrel found that the use of pretests, interim testing, and a formal posttest evaluation of their training program demonstrated clear learning and strengthened their program.[14]

The public health infrastructure relies on people who have the skills to deliver and evaluate interventions. Common teaching methods, such as lectures, limited homework assignments, and final exams, may not maximize learning and do not enable assessment of learning attributable to specific teaching methods. Thus, research methods should be applied to evaluate public health teaching methods to refine them continuously over time. We propose an educational model to assess behavior change over time and describe a course that effectively teaches principles of research design using PSI and Socratic Methods.

METHODS

Participants

Graduate students' performance in Public Health 607 (Research Methods and Proposal Writing) was assessed over an 11-year period (1992 through 2002). Approximately 62% of each class was female, with class sizes varying from 16 to 35 students. Twenty-five out of the 303 students were in the process of or had already completed a doctoral degree. Table 1 shows demographics and student academic backgrounds.

Procedures

Data collection and design. The class was taught once a year with a pretest/posttest design replicated across

Table 1. Class size, gender makeup, GPA, GRE, pretest, and posttest scores over 11 years

Year	*Class size*	*Gender (percent female)*	N	*GPA M (SD)*	N	*GRE verbal M (SD)*	N	*GRE quantitative M (SD)*	N	*Pretest M (SD)*	N	*Posttest M (SD)*	N
1992	25	88	25	3.0 (0.40)	15	480 (70)	14	538 (78)	14	21.08 (7.98)	25	78.15 (17.13)	24
1993	35	74	35	2.9 (0.33)	29	508 (73)	27	530 (101)	27	12.21 (5.60)	35	80.00 (8.57)	35
1994	27	75	24	3.2 (0.40)	24	485 (79)	21	562 (115)	21	9.83 (4.42)	27	84.81 (7.89)	27
1995	28	78	27	3.0 (0.42)	23	494 (110)	23	523 (114)	23	13.21 (5.24)	28	85.61 (7.76)	28
1996	16	62	13	3.0 (0.32)	13	470 (61)	12	557 (103)	12	17.50 (10.23)	16	82.75 (10.76)	16
1997	25	79	24	3.2 (0.39)	18	486 (82)	16	527 (120)	16	14.86 (6.78)	25	89.30 (7.69)	23
1998	31	81	26	3.4 (0.37)	27	495 (105)	22	553 (94)	22	21.31 (8.49)	31	83.15 (12.59)	31
1999	31	80	30	3.5 (0.34)	26	485 (85)	23	564 (91)	23	17.74 (5.84)	31	89.44 (6.77)	29
2000	25	81	21	3.4 (0.34)	22	497 (88)	20	584 (94)	20	14.38 (10.69)	25	85.50 (8.86)	25
2001	32	78	32	3.3 (0.37)	30	481 (96)	27	559 (130)	26	21.02 (8.19)	32	78.25 (9.96)	32
2002	28	82	28	3.4 (0.39)	21	426 (109)	17	529 (125)	16	16.48 (9.35)	28	79.43 (9.22)	28
Mean, total, or percent	303	78	285	3.2 (0.41)	248	485 (90)	222	548 (107)	220	16.32 (8.37)	303	83.14 (10.59)	298

GPA = grade point average

GRE = graduate record examination

SD = standard deviation

M = mean

the 11 years. Students entering the MPH program came from different fields with at least a bachelor's degree, but many held master's or doctoral degrees. A comprehensive pretest consisting of short-answer and essay items was administered on the first day of class to measure students' prior knowledge of research design. Questions covered content that ranged from concepts of measurement and sources of variance, to operational means of obtaining associations, to nonexperimental and experimental designs. The questions measured knowledge of research designs and related concepts, proper use of designs to applied circumstances, and ability to critique research methodology and develop novel studies. The Figure shows example questions. Variations of the same questions were included in a comprehensive final exam.

To encourage high effort on the pretest, students were told that anyone who scored 80% or higher would be exempt from quizzes and that a one-letter grade bonus would be assigned to their final grade in the course. No student met the 80% criterion. Graduate assistants and the instructor graded the tests with discrepancies judged by the instructor. Students' gender, prior degrees, graduate record examination (GRE), and grade point average (GPA) were used to predict change in examination performance.

Students also evaluated 13 aspects of the class and instructor at the end of every semester. These evaluations were administered by volunteer students. The class instructor was not present during the evaluations and was blind to student ratings. Completed evaluations were given to the graduate school of public health administrator, who produced aggregated summary scores the following semester. Evaluation questions are provided in Table 2. Students responded to each item on a five-point ordinal scale, with anchors of 1 = strongly disagree to 5 = strongly agree.

Class content. The class emphasized Hill's postulates of causal inference and their foundation for research.[15] Designs taught included fully controlled trials, quasi-experimental, within subject time series, case control, cross-sectional, cohort, and nested case control. Each design was evaluated on its strengths and weaknesses for concluding causal associations, including strength of association, consistency of association, temporal order, ruling out alternative explanations, and theoretical plausibility. Concepts such as variance, reliability, validity, fidelity, bias, and confounding were reviewed in the context of each design.

Multicomponent intervention. The class met for two hours and 40 minutes every week for 15 weeks. Six short-answer/short-essay quizzes were administered every other week. Quiz questions required students to generalize from major course concepts and provide novel examples to demonstrate understanding. The questions were similar in format and content to questions on the pretest and final exam. Students who scored less than 80% to 85% (the criterion varied from semester to semester) on a quiz had an option to take a second form of the quiz the following week. Overall, quizzes accounted for 40% of each student's grade in the course.

Lecture and lab time were divided evenly. Lecture was an interactive period where the instructor, using the Socratic Method, asked the students increasingly demanding questions. Correct answers were praised, while incorrect answers prompted the instructor to probe for more basic understanding while avoiding explicit criticism. The main topics of discussion were concepts presented in the readings. Lab time provided clarification of concepts by the teaching assistant in a more relaxed environment. Students were able to practice using the concepts and ask questions in smaller groups or a more casual environment. Exercises were used to provide research experience. Guest speakers offered specialized information such as library research methods and ethics in research.

Over years of administration, two to three texts were

Figure. Examples of questions presented on pretests and posttests

1. Define what is meant by an association between two variables, and give a NOVEL example of both a positive and a negative association.
2. Using a NOVEL example, explain how the following designs meet some or all of Hill's postulates.
   (a) Case control
   (b) Cross-sectional
   (c) Cohort
   (d) Quasi-experimental
   (e) Multiple baseline
   (f) Reversal design
   (g) Randomized controlled trial
3. Explain why many practitioners do not believe results from research and do not adopt new treatment or prevention procedures based on research results using the concepts of variance and ecological fallacy.
4. Define and give a NOVEL example of (*a*) reliability and (*b*) validity.

Table 2. Students' aggregated quantitative evaluations from 1997 to 2002

Question[a]	*Median score*	*Median range* *Minimum*	*Maximum*
Q1 Course objectives and procedures for evaluation were made clear at the beginning of the semester.	4.25	4.0	5.0
Q2 Content, assignments, activities, and evaluation procedures were appropriate for course objectives.	4.00	4.0	5.0
Q3 Content (lectures, handouts, reading assignments) included current, state-of-the-art information.	4.00	4.0	4.0
Q4 Course resources (text, handouts, guests, slides, film) were useful.	4.00	3.0	4.0
Q5 Planned course content was reasonably covered by the end of the semester.	4.00	4.0	4.0
Q6 Overall, the course was personally rewarding.	4.00	4.0	5.0
Q7 Instructor was knowledgeable on the subject matter.	5.00	4.5	5.0
Q8 Instructor was prepared to lead class activities.	5.00	4.0	5.0
Q9 Instructor was professional and understanding in relationships with students.	4.50	3.0	5.0
Q10 Instructor communicated effectively in class and/or conferences.	4.00	3.0	5.0
Q11 Instructor encouraged interaction (i.e., questions, expression of opinion).	5.00	4.0	5.0
Q12 Instructor provided adequate feedback regarding student performance in course.	3.75	3.0	4.0
Q13 Overall, this instructor was an effective teacher and facilitated learning the material.	4.00	4.0	5.0
Total	4.00		

[a]Responses were based on a five-point scale: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree.

used. The primary text was a current edition of Designing Clinical Research.[16] The second text emphasized quasi-experimental and time-series designs.[17] These were supplemented by research articles to illustrate issues and methodological errors.

In addition to answering specific questions concerning each reading, homework assignments required incremental preparation of components of a grant application based on the PH398 form used by the National Institutes of Health. These included specific aims, operational definitions, literature review, research design, subjects, procedures, and protection of human subjects. Each student was also required to prepare a written critique of a published article. Critical feedback was provided on writing style, use of concepts, design, and understanding of methodological issues. These assignments were iterative and cumulative, leading to both a draft research proposal and refined article critique by the end of the semester. Homework was worth 15% of the semester grade.

Statistical analyses. Descriptive statistics such as percents, means, and medians were computed for each class. Separate analyses for classes and students as the unit of analyses were conducted. An ANOVA model was used to evaluate whether classes differed by year on pretest and posttest scores, GPA, and GRE scores. Student change scores were computed by subtracting pretest from posttest scores, with mean differences evaluated by a paired sample *t*-test. A Pearson correlation coefficient determined associations among students' covariates, test scores, and change scores. We estimated a regression model with students' pre- to posttest change as the dependent variable and pretest, gender, class year, doctoral status, GPA, and GRE scores used as covariates. Strength of each predictor was estimated by standardized betas. All analyses were performed using SPSS.[18]

RESULTS

Table 1 presents a summary of class size, proportion of female students, GPA, GRE, and pre- and posttest scores over the 11 years. Mean GPA scores ranged per class from 2.9 to 3.5, based on a four-point scale. Mean class GRE verbal scores ranged from 426 to 508, and quantitative scores ranged from 523 to 584. For all 11 years combined, the total mean GPA was 3.2 (standard deviation [SD] = 0.41) and the mean GRE verbal and quantitative scores were 485 (SD=90) and 548 (SD=107), respectively. An ANOVA determined classes differed on mean GPA scores $F=(10, 247)=6.03$, $p<0.001$. However, GRE verbal and quantitative scores were not significantly different among years.

Class pretest scores were consistently low and ranged from 9.8% to 21.3% correct, while posttest scores were consistently higher, ranging from 78.2% to 89.4% correct. The mean pre- and posttest scores were 16.3% (SD=8.4) and 83.1% (SD=10.6) correct, respectively. With limited variance around the posttest scores, a high proportion of students attained more than 75% correct by the end of the semester. Pre- to posttest change ranged from 57.1% to 75.0%. The 11-year mean increase from pre- to posttest for all students was 66.8%. This difference was significant $t(297)=98.72$, $p<0.001$ as expected using a paired sample

t-test. For comparison, students pursuing or holding a doctoral degree had comparable pretest (M=23.26%, SD=7.96), posttest (M=86.56%, SD=10.52), and change (M=63.30%, SD=10.52) scores.

To estimate the likelihood that consistent change in scores from pre- to posttest was attributable to the class methods, a binomial probability with a 50% chance of changing at least 50 percentage points was computed for 11 consecutive years of change. The probability of obtaining the observed result was less than 0.001.

A Pearson correlation coefficient was used to determine associations among students' characteristics, test scores, and change scores. There was a significant negative correlation between students' class year and pretest scores ($r=-0.19$, $p=0.003$), but no significant correlation between class year and posttest scores ($r=-0.02$, $p=0.78$). Significant positive relationships were found between students' pretest scores and GRE verbal ($r=0.31$, $p<0.001$), GRE quantitative ($r=0.25$, $p<0.001$), and GPA ($r=0.37$, $p<0.001$) scores. Similar significant positive associations were seen with students' posttest scores and GRE verbal ($r=0.26$, $p<0.001$), GRE quantitative ($r=0.30$, $p<0.001$), and GPA ($r=0.34$, $p<0.001$) scores. While GRE quantitative scores had a marginally significant positive correlation with the pre- to posttest change scores ($r=0.11$, $p=0.09$), GRE verbal and GPA scores were not associated with the students' change scores ($r=0.03$, $p=0.64$ and $r=0.05$, $p=0.45$). Pretest, GPA, and GRE scores were included in further multivariate analyses.

Table 3 presents students' change scores regressed on predictor variables. The model explained 29.4% of the variance. Variables significantly associated with change scores included students' pretest scores (standardized beta = −0.53), GPA (standardized beta = 0.24), GRE quantitative score (standardized beta = 0.19), and class year (standardized beta = −0.15). The results indicate that, for every one standard deviation decrease from the mean pretest score, posttest scores increased 0.53 SDs, after controlling for all other variables. This suggests that students with poorer understanding of the material at pretest may benefit most from the class. Moreover, students with higher GPA and GRE quantitative scores showed greater change.

Students ranked qualitative aspects of the class each year. However, data were available only from 1997 to 2002 (Table 2). Overall, students ranked the class favorably. Median scores ranged from 3.0 to 5.0, with the total median score over the six years equaling 4.0, or "agree," with the 13 positively framed evaluation questions.

DISCUSSION

This article describes an effective way to teach research design to graduate students in public health. The teaching method specified objectives, frequent assessments of student behavior, individualized feedback, and the opportunity to do assignments until mastered. Pre- to posttest change demonstrated dramatic increases in competencies by semester's end. These changes were replicated over 11 consecutive cohorts.

On the pretest, most students demonstrated a lack of conceptual understanding of public health science. Many students demonstrated what might best be described as a memorized understanding of procedures with little understanding of how specific procedures controlled for error, or without the ability to use novel

Table 3. Linear regression model for students' change scores[a]

Variables[b]	*b*	*SE*	*ß*	*95% CI*	*P-value*
Pretest score	−0.770	0.10	−0.53	−0.58, −0.96	<0.001
GPA	6.860	1.98	0.24	2.95, 10.77	0.001
GRE quantitative	0.021	0.01	0.19	0.01, 0.04	0.008
Year	−0.520	0.24	−0.15	−0.04, −0.99	0.033
Doctoral degree	10.980	9.86	0.07	−8.46, 30.43	0.267
GRE verbal	0.005	0.01	0.04	−0.01, 0.02	0.585
Gender	−0.890	1.91	−0.03	−4.65, 2.87	0.640

[a]$R^2 = 0.294$

[b]Variables are ordered according to beta weight, from highest to lowest.

b = unstandardized coefficient

SE = standard error

ß = standardized coefficient

CI = confidence interval

GPA = grade point average

GRE = graduate record examination

methods to solve research problems. While this class did not equip students with advanced research ability, it moved them in that direction through active participation and feedback. The pretest also showed the need for more training of most behavioral science majors in public health, including an important proportion of students who had completed relatively advanced training in medicine. This feedback tended to have a humbling effect on students that motivated them to participate fully in the class.

The class was based on Keller's Personalized System of Instruction and the Socratic methods. Teaching assistant tutorials, repeated quizzes, and the Socratic methods resulted in reliable mastery of the content. Most students ended the class with a B grade or higher. The few who obtained a C were invited to repeat the class and all obtained a B or higher with replication. Moreover, those who obtained a C grade demonstrated remarkable change from about 10% correct answers on pretests to more than 70% correct at posttest.

The bivariate analyses showed weak relationships between most demographic and baseline knowledge characteristics and final change from pretest. Scores at pretest and posttest performance tended to be weakly related to pre- to posttest change, but this is essentially a mechanical relationship as they are components of the change score. Examination of GRE and GPA scores showed weak prediction of change in bivariate analyses. This suggests that they did not predict change in the context of this class.

The multivariate analysis showed that pretest scores, GPA, quantitative GRE scores, and year of enrollment were significant predictors of change scores. However, pretest scores are again a function of the mechanical relationship as a component of the change score, providing more opportunity for change with lower-level pretest scores. GPA and GRE predictors are face valid and probably reflect past academic skills, both specific knowledge such as quantitative skills, and general knowledge of how to study for classes. Year of enrollment may reflect subtle changes in the demography of the students or in the teaching procedures. However, all of these factors explained less than 30% of the variance in the pre- to posttest performance changes. This provides circumstantial evidence that the changes achieved were due to the teaching procedures. This evidence is strengthened when one examines the role of doctoral training (mostly physicians), verbal GRE, and gender, none of which reached significance as predictors of change. These findings suggest that individuals with a relatively high GPA and relatively advanced degrees, including a doctoral degree, can benefit from a teaching technology of the sort tested here.

Limitations

This study lacked random assignment to a comparison group for more complete control for alternate explanations of change. However, the class included interactive feedback through biweekly quizzes, frequent student and instructor interaction, homework, and tutoring. These repeated interactions served as student performance "process measures" that corroborated the pre- to posttest changes observed. Moreover, our results showed that the likelihood of obtaining 11 consecutive years of substantial change was less than one in 1,000, with students differing in academic achievement and backgrounds. Although the efficacy of PSI and the Socratic Method were not compared to other pedagogical methods, the current research provides substantive evidence for attributing change in performance to the current instructional methods, and suggests a high level of generalizability.

Standards for teaching public health

The IOM called for more quantitative instruction in public health. This article provides a model for well-researched PSI and related Socratic teaching methods that can be applied to all graduate public health instruction.[19] While more formal control procedures could be used in the experimental evaluation of similar classes, we recommend that, at a minimum, objective measures of knowledge be assessed routinely on a pretest and posttest basis. Doing so provides quasi-experimental evidence of learning attributable to the specific class, and it provides a model to students for the routine use of research methods in the delivery of services. These procedures also lend to use by academic personnel committees for remedial assistance for instructors in those instances where outcomes do not appear satisfactory. Such procedures should supplement subjective student evaluations. The Association of Schools of Public Health and the Council on Education in Public Health might consider criteria for evaluating public health instruction that follows this model. Such policies and teaching procedures could meet the standards recommended by the IOM.

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