Quantitative Reasoning Across a College Curriculum

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Today there is widespread concern about the inability of students of all ages to reason effectively with quantitative concepts. The initiative reported here represents the efforts of a university program to teach quantitative reasoning throughout the full spectrum of an undergraduate core curriculum, including natural sciences, social sciences, and the humanities. At the heart of this approach is an appreciation of the role of quantitative reasoning in domains as diverse as history and geology and the belief that quantitative reasoning is best taught in meaningful contexts. Thus, exercises to promote quantitative reasoning are generally adapted to serve course goals and are designed to elicit active participation from students. I also contend that small yet meaningful exercises in quantitative reasoning can have a large impact on students when they are encountered across a range of disciplines and throughout a sequence of courses within a discipline.

The phrase *quantitative reasoning* is used here to refer to a wide range of mental abilities, which include the following: facility with measurement and estimation, a sense of scale, an understanding of basic probability theory and statistics, and a subjective sense of ease in reasoning with numbers. For these purposes, we are not concerned with the skills needed for calculus and higher mathematics.

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To aid our thinking, it is useful to consider four interrelated aspects of quantitative reasoning:

learning from data,
quantitative expression,
evidence and assertions, and
quantitative intuition.

Learning from data refers to the skills associated with collecting and analyzing data, particularly in the natural and social sciences. Quantitative expression is the ability to use and comprehend quantitative language in a variety of contexts. Facility with evidence and assertions allows one to comprehend which conclusions may be reasonably drawn from a body of evidence. Finally, developing quantitative intuition refers to developing a "feel" for numbers and other quantitative concepts.

Although it is useful to consider these four aspects of quantitative reasoning separately, it is important to realize that they are inherently interconnected. For example, reading an empirical research article requires the ability to learn from data, comprehend quantitative expressions, evaluate evidence and assertions, and apply quantitative intuitions. For the sake of clarity, this article is divided into several sections describing the background of our program, four aspects of quantitative reasoning, a discussion of several exercises, and our experiences implementing the plan.

The Setting

We are now implementing this plan for quantitative reasoning across the curriculum in the School of Interdisciplinary Studies (SIS) at Miami University. It stems, in part, from a comprehensive assessment of the program (Schilling and Ellison 1987). Surveys of alumni and standardized tests indicated that SIS students are often uncomfortable using quantitative and numerical concepts in their reasoning and problem solving. With the aid of funding provided by the Ohio Board of Regents through an Academic Challenge grant, this plan for quantitative reasoning across the curriculum was developed and endorsed by the SIS faculty in the spring of 1990.

The School of Interdisciplinary Studies (or Western College Program) at Miami is widely recognized for innovation in undergraduate education. The program seeks to integrate insights from several academic disciplines in the study of social, scientific, humanistic, and artistic issues. Students pursue interdisciplinary studies through a sequence of required team-taught interdisciplinary core courses, an individual course of study, and a year-long senior project. The program is organized around three core areas: natural systems, social systems, and creativity and culture, which includes the arts and humanities. The program serves approximately 250 majors and fulfills the liberal arts requirements of over fifty environmental design (architecture) students each year.

This plan for quantitative reasoning is embedded in the program's core curriculum. These core courses are taken in the first and second years and are designed to introduce students to interdisciplinary thinking about natural systems, social systems, and the humanities. Our goal is to introduce students to key aspects of quantitative reasoning and to provide a foundation for further development. For this reason, the plan emphasizes those aspects of quantitative reasoning that enable students to advance academically in a number of directions and those that are most important to the educated citizen.

Quantitative Reasoning Skills

Learning from Data

Perhaps the most exciting aspect of science is the ability to ask questions of nature and get answers from data. Yet many students lack the basic conceptual and methodological skills for learning from data. Acquiring the tools for collecting and analyzing data in the natural and social sciences can be an empowering experience. It gives students the ability to test their own ideas about the world and make new discoveries. Skills of data collection include an understanding of the notion of hypothesis testing and specific methods of inquiry such as experimentation and systematic observation. In both the natural and social sciences, descriptive and inferential statistics are powerful tools. Thus, students need to learn to use and calculate descriptive statistics such as means, medians and correlation coefficients, as well as basic inferential statistics such as *t*-tests and chi square.

Students will benefit from greater exposure to statistical reasoning in several ways. First, because basic statistics are widely used in a number of domains, acquiring these skills will enable students to advance academically in many directions. Also, there is empirical evidence from the psychological literature indicating that even a small amount of statistical training can have a measurable impact on everyday reasoning. Nisbett, Krantz, Jepson, and Kunda (1983) report that "training in statistics has a marked impact on reasoning. Training increases both the likelihood that people will take a statistical approach to a given problem and the quality of the statistical solution." Fong, Krantz and Nisbett (1986) found that a brief lesson in statistics produced significant "transfer of training" to a "wide variety of problems of an everyday nature." Finally, the ability to reason with statistical data is a vital component of effective policy making. Students who aspire to have an impact on the political world and/or administrative decision making would greatly benefit from a working knowledge of basic statistics.

Embracing the notion that good teaching encourages learning by doing, we give students many experiences in developing hypotheses and collecting and analyzing data in the natural and social sciences. Such experiences may include experiments, observational studies, and surveys. Learning about statistics is more meaningful—and fun—when students are analyzing real data that they themselves collected. Whenever possible, it is important to involve students in testing their own hypotheses. An effective strategy is to assume the role of research consultant, working very closely with groups of students in their early efforts, and reducing the degree of instructor involvement in upper-level courses. I have used this approach effectively with first-year students in both the natural and social sciences with problems as diverse as freshwater ecology and the effects of subliminal messages on behavior (Wolfe, forthcoming).

By teaching in context, we create the demand for statistical and methodological problem-solving techniques.

Despite the potential for empowerment, for many students, a traditional course in statistics is a painful and meaningless experience. This is because traditional statistics courses are focused almost exclusively on computation and rarely on what statistics can do for the student.

Our approach differs from typical statistics and methods courses in two important respects. We have a commitment to teaching in context. It does little good to give students tools without showing them how these tools are useful for solving their problems. By teaching in context, we create the demand for statistical and methodological problem-solving techniques. Second, we focus on hypotheses generated by students, which encourages them to develop testable propositions about the world. Learning to ask empirical questions in a testable form is an exciting process. Getting answers to those questions requires some degree of statistical sophistication. And both activities encourage students to make the tools of learning from data their own.

Quantitative Expression

In many domains, it is useful to express concepts in quantitative language. Thus, familiarity and comfort with quantitative expression is essential for understanding, and participating in, work in many fields. An important dimension of quantitative expression is a working knowledge of various units of measurement. For example, students should understand units such as milliseconds, light years, calories, and constant dollars. Students benefit from working with a variety of measures and learning about the rationale for their use. In some cases, it may be useful to discuss explicitly the historical development of measurement within a given field.

Another aspect of quantitative expression is the ability to express quantitative concepts visually. A collection of numbers is, generally, difficult to understand. However, to the trained eye, graphs often make intuitive sense. Thus, it is useful for students to learn to read and produce a wide variety of graphic representations of quantitative concepts. For example, starting with raw data, students should learn to produce histograms, pie charts, and scatter plots, and know which are appropriate for which kinds of data.

Maps are another powerful means of representing data in visual terms. They are extremely useful for expressing geographical, social, and ecological concepts in context. Yet students are generally unschooled at reading maps, and particularly at making them. Map-related exercises, such as tracing the migratory range of Monarch butterflies, sources of acid rain, or the location of natural resources build visual and quantitative skills and help students see the world in new ways.

A third dimension is an understanding of various scales and distributions. Because integers can be used on nominal, ordinal, interval, and ratio scales, it can truthfully be said that "one does not always equal one." People frequently make inappropriate inferences due to misunderstandings about different scales. For example, when talking about the weather, 60° F is not twice as warm as 30° F. Similarly, people often think in terms of idiosyncratic examples rather than distributions. Our understanding of the world is strengthened when we realize that some variables, (such as people's height) are distributed normally, while other variables (such as people's income) are part of skewed distributions. Students should work with a variety of scales and distributions, with special attention paid to their similarities and differences.

Evidence and Assertions

Raw data alone, whether qualitative or quantitative, tell us nothing about the world. They must be interpreted by human beings. Of course, there are no universal rules for arriving at truth, but there are some general guidelines for evaluating assertions based on claims of evidence. One set of guidelines stems from conditional and syllogistic reasoning. These alert us to common fallacies in reasoning and decision making. For example, a common mistake is the conversion error whereby people assume that statements such as "all dogs are animals" imply that "all animals are dogs" or that "the probability that an African American is poor" is equal to "the probability that a poor person is African American."

Another pitfall stems from probability theory. A common error in probabilistic reasoning is the base rate fallacy. This refers to people's tendency to ignore base rate information (describing the overall or unconditional probability of events) in making probability judgments, (Kahneman and Tversky 1972; Wolfe in preparation). For example, in assessing the probability that a specific airplane might crash, (i.e., the one you're flying in) it is useful to consider the overall safety record of airplanes. We should teach our students to pay special attention to the construction of arguments and the perils of fallacious reasoning.

Diagnostic reasoning requires the careful consideration of evidence and assertions. Diagnostic reasoning is the ability to arrive at specific differential conclusions on the basis of evidence. A powerful tool for diagnostic reasoning is the 2 × 2 table (see Table 1). The media frequently report on tests for AIDS or drugs. Yet they seldom report that such tests are inherently susceptible to two types of errors: *false alarms*—telling people they have AIDS when they really don't, and *misses*—telling people they don't have AIDS when they really do. Similarly, such tests produce two kinds of appropriate response: *hits*—telling people they have AIDS when in fact they do, and *correct rejections*—telling people that they don't have AIDS when in fact they don't.

Thinking in terms of the 2 × 2 table has important ramifications for issues as different as drug testing and jury verdicts. Although we often do not have the numbers to plug into the table, even drawing the empty grid often allows us to think clearly about issues such as accuracy and fairness.

Table 1.—2 × 2 Contingency Table

		Test Result	
		Positive	Negative
True state of the world	Positive	Hit	Miss
	Negative	False alarm	Correct rejection

Quantitative Intuition

It is widely believed that some people have a good "feel" for numbers. Many people (including some skilled mathematicians) seem to think that quantitative intuition is a natural gift. It is my contention that such intuitions are learned and that they can, and should, be taught. Quantitative intuition refers to a subjective sense of ease and comfort with quantitative concepts and a good sense of when numbers seem right.

Part of quantitative intuition is an appropriate sense of scale. An important dimension of developing a sense of scale is grounding numbers in everyday experience. For example, people frequently talk about millions, and billions, and trillions as if they were practically synonyms for a "big number." An interesting exercise to gain a better feel for these numbers is to calculate how old someone is, in days, after their first million seconds of life and then to calculate how old they are, in years, after a billion seconds—try this!

A second facet of quantitative intuition is the ability to make order of magnitude estimates. These "ball park estimates" are extremely useful for checking the accuracy of assertions, checking our own calculations, and applying the power of quantitative reasoning to everyday problems. Yet students are rarely taught how to make such estimates. The estimation starts with a rough sense of the quantities involved in a problem and a sense of scale. For example, if asked about the distance between Chicago and Seattle, a person may reason that it is about 3,000 miles from coast to coast, and that Chicago is about one-third of the way across. So the distance is roughly 2,000 miles (the actual distance is 2,052 miles).

Frequently, students have the prerequisite knowledge to make such estimates, but they fail to apply it. One approach to developing this skill is specifically to ask students to make rough estimates in a variety of contexts and to estimate the answers to quantitative questions before they do their calculations. Through practice and feedback, estimation skills can be improved.

Stochastic intuition is another important aspect of quantitative reasoning. The phrase, *stochastic intuition,* refers to a sense of the probability or frequency of events. People are often impressed by "amazing coincidences" that, upon reflection, really are not so amazing after all. For example, the probability that two students in a class of twenty-three should share the same birthday is about 50 percent (Paulos 1988). Yet such discoveries are often accompanied by a sense of awe. As with order of magnitude estimation, stochastic intuition can be improved by practice. In addition, learning basic probability theory helps develop an understanding of statistics and can enrich one's everyday thinking.

A fourth dimension is the appropriate use of heuristics or short cuts in judgment and decision making. People often exhibit systematic biases in their judgments because of faulty heuristics. For example, people often behave as if they believe in an erroneous "law of small numbers," the belief that a small number of observations adequately captures the variability of a larger population, (Tversky and Kahneman 1974). This leads to prejudiced generalizations and is in direct conflict with the statistical "law of large numbers."

Implementation: Our Experience

The process of making this plan our own has been rewarding for some and a struggle for others. Undoubtedly, our response to the challenge will evolve as we gain experience. I would like to discuss some of the issues associated with implementing this plan for quantitative reasoning in the humanities, natural sciences, and social sciences. I will also report on some exercises we have used to promote quantitative reasoning and the experiences of students and faculty.

Humanities

"Is this relevant to the humanities?" may be a question for some faculty members teaching in our creativity and culture area. Not surprisingly, many people in the humanities find it difficult to find meaningful ways of integrating quantitative reasoning into their courses. One approach is to include quantitative concepts in broader discussions of evidence and assertions. In a sense, the humanities are largely devoted to issues of evidence and assertions. For example, issues such as whether there are universal themes in human history or whether all ideas are inherently embedded in the context of gender, race, and class are often addressed in the humanities.

Occasionally, quantitative concepts enter these discussions in the form of opinion polls, divorce rates, and the like. Rather than dismissing such concepts, or assigning them the privileged status of "fact," such occasions can be opportunities for education. By attending to the similarities and differences between quantitative and qualitative approaches to evidence and assertions, and by encouraging students to think critically about quantitative concepts, humanities teachers can be effective teachers in quantitative reasoning.

Addressing the difficulty of teaching quantitative reasoning in the humanities, Professor Gene Metcalf writes:

> One reason it's hard is that I'm so bad at math. Math skills are infrequently applied by scholars in my field. I'm not sure how you could do it. However, if by quantitative you also mean the quantities around you, say, the objects in a house, then that's what my course is all about. Space is always culturally quantified.

A Puritan's House. Professor Metcalf developed an exercise that gave students a better feel for life in a Puritan community and the relationship between the material world and culture.

In the language of our plan, this is an exercise in quantitative intuition and expression. The context was a course on the history of the American home. Students were divided into three groups to conduct library research and present their findings to the class. The first group had the task of finding the physical dimensions of a typical Puritan's house in a specific New England community. The second group researched the kinds of objects likely to be found in the house, and the third group researched how many people would have lived in the house and other questions about the community. In class, the students used masking tape to map out the dimensions of the house on the floor. For example, a typical house might measure fifteen by twenty feet, a single chest might be the only large piece of furniture (no chairs or tables), and the number of people was often six or seven (Demos 1970). Students also mapped out the size and location of objects in the house, and seven students spent the entire class period within the confines of the taped lines.

Having a physical representation of the house, and the visceral experiences of spending time within its "walls," added a new dimension to discussions of everyday life. It also raised questions about a number of issues such as the Puritan child's knowledge of sexuality. Professor Metcalf writes:

> People learn as much from interacting with things as from reading about them. However, just because you stand in their space doesn't mean you experience it the same way that they did. For them, space was very different than it is for us. The ethnographic understanding is also needed to put things in context.

Students performed an exercise that gave them a better feel for life in a Puritan community and the relationship between the material world and the culture. I consider this an exercise in quantitative intuition and expression.

Approaching quantitative reasoning from the perspective of the humanities has great potential for fostering intellectual development. Even though the humanities may seem to provide relatively few opportunities for developing quantitative reasoning, the opportunities that do arise will be among the richest.

Natural Science

"We've been doing this all along" may express the sentiments of some natural science faculty. Although this is undoubtedly true about some aspects of quantitative reasoning, important dimensions of reasoning with quantitative concepts are generally ignored in science education. One of the most serious failings is in the area of quantitative intuition. The well-known difficulty that math students of all ages have with word problems exemplifies the inadequacy of the way that we teach science and math. Undergraduate science courses also sometimes fail to get students to think about evidence and assertions. Science teachers frequently take a "cookbook" approach to lab work, rather than challenge students to reason about scientific rules of evidence and the inferences scientists draw from data.

One approach to developing quantitative intuition is to help students relate abstract quantitative concepts to direct perceptual experience. For example, Charles and Ray Eames's *Powers of Ten* (1977) is an excellent film representing the scale of the universe from the nucleus of a carbon atom to a sea of galaxies. The film and the book of the same title by Morrison and Morrison (1982) also help students grasp the meaning of very large and very small numbers.

Moon Lab. Some recently developed laboratory exercises promote quantitative intuition and help students develop the ability to reason about evidence and assertions. The moon lab developed by Cummins, Ritger, and Myers (1992) is an exercise that requires students to make detailed observations of the moon in order to test the incorrect hypothesis that the moon revolves east to west around the earth. By methods of observation determined by the students, they test the hypothesis of lunar revolution and discover approximately how many degrees the moon revolves per night. Students then develop a scale model of the earth-sun-moon system using a flashlight, a small pumpkin, and a squash to demonstrate the phases of the moon. They learn that if the model were true to scale the flashlight/sun should be over 2 kilometers distant, and the squash/moon should be about 2 meters from the pumpkin/earth.

Because the earth's rotation affects our perceptions of the moon, a task that at first seems simple actually requires students to think hard and develop systematic methods of observation. The results of these observations are generally counterintuitive for students, which forces them to reconcile misconceptions with the evidence of their senses. Professor Hays Cummins comments on his experience: "Students gain a sense of scale and empowerment in quantitative exercises. Students learn that they too can do science when they are taken from the role of spectator to that of active participant."

Wolfe's (1992) flipping Frisbees exercise allows students to develop statistical intuitions by literally seeing a population and samples taken from it. In this exercise, students sampled the number of clover flowers in a grassy field with a Frisbee. Students tossed a Frisbee across the field and counted the number of clover flowers under the Frisbee. After each student had collected data for ten trials, we went indoors and from the data drew a histogram that resulted in a curve resembling a normal distribution. Next I set up a frequency distribution table and used this as the basis for having students calculate the mean and standard deviation.

Students gained direct experience with the relationship between the mean and standard deviation that they calculated, the histogram they drew, a set of Frisbee samples, and a population of clover flowers.

When more than one class used this exercise, we have been impressed with how similar the results of different sample sets can be. Professor Christopher Myers used this exercise in his natural science course. He notes:

> One thing that strikes me about the discovery-oriented exercises is that quantitative reasoning is taught as an intuitive process, an extension of normal habits of thought, rather than as a system of arcane symbols with doubtful application. I really think students get more out of these hands-on experiences, and their learning is reinforced by the systematic approach to quantitative reasoning at Western.

A Timeline of Three Miles? Another exercise that had a profound impact on students' quantitative intuitions is Ritger and Cummins's (1991) use of student-created analogies for comprehending geologic time. It is extremely difficult for students to comprehend the vastness of the 4.6 billion year history of earth. Even more mind boggling is the relative recency of seemingly distant events such as the emergence of the first mammals about 100 million years ago and the first true *homo sapiens* about 250,000 years ago.

In the following exercise, students were asked to create their own analogies for the age of the earth and map important events in natural history onto a scale with which they are intimately familiar. For example, some students developed the analogies to the distance from home to school, the span of their own lifetime, or the number of words in a favorite book. Students reported a feeling of awe in response to comprehending the age of the earth and the brevity of human history. To illustrate with a timeline if the timeline were nearly three miles long (5,000 yards), "the thickness of a pencil line will probably encompass all of human history. In [students'] calculations, human history will probably be entirely contained in numbers that lie four or five or six positions to the right of the decimal point—numbers that in the past they have most likely rounded off to zero!" (Ritger and Cummins 1991, 10).

It is tempting for science teachers to believe that a student's deeper understanding of quantitative concepts is strictly a function of innate intelligence. It is also easy falsely to assume that students share the instructor's quantitative intuitions. In either case, the result is miscommunication and ineffective teaching. With quantitative reasoning, as in other domains, students are not empty vessels waiting to be filled. An understanding of their initial misconceptions, and work on developing their quantitative intuitions can greatly improve their understanding of essential quantitative concepts.

Social Science

One possible objection to promoting quantitative reasoning in the social sciences is that it forces the professor to take a sociometric approach. Part of this concern is that teaching quantitative reasoning in the social sciences requires a commitment to logical positivism, that is, the philosophy that positive knowledge is based on natural phenomena or upon facts derived by the methods of the empirical sciences.

This is not the case. For example, a course developed on principles of feminist pedagogy called "By/On the Margins: Perspectives on Power, Oppression, and Liberation" made good use of an exercise on the working poor. This exercise, developed by E. Higginbotham of the Center for Research on Women at Memphis State University, had students develop a poverty-level budget for a family of four in Butler County, Ohio. Groups of students received scenarios about the working poor. They were given information about the composition of the family and their income. The students had to determine where these people would live, work, and shop, and how they would travel from place to place. They also had to develop a monthly budget for the family including food, housing, transportation, utilities, and medical expenses. This exercise gave students a new understanding of some aspects of poverty and illustrated how quantitative reasoning can help them gain insights into difficult social issues.

Speaking from her experience, Professor Enid LaGesse reflects:

> Most of our student population is not aware of the large numbers of "working poor," especially in our geographic location. I like to combine both action and theory. If I had my druthers, for action I would have each student do a stint with VISTA, or local community agencies. Since that's often not possible, doing library and quantitative research is a means of learning and applying theory in the classroom. Students are reading about the working class while building a demographic profile of this group. In theory, they are putting themselves in the place of the "working poor." One of my goals is to help them develop a greater sense of both qualitative and quantitative work.

Another exercise to promote quantitative expression and learning from data was used in a sophomore interdisciplinary social systems course called "Social Movements and Strategies for Change." This group project on demographics and social movements asked students to determine how changes in U.S. population distribution were likely to affect a social movement of their own choosing. My team teacher, Bill Newell, and I provided students with state-by-state data on a set of demographic variables such as population change, past voting behavior, and median income. Their task was to (1) find state-by-state quantitative data about a social movement of their own choosing, (2) analyze the data in terms of the demographic data that we provided, (3) build a case *supported by data* on the ways in which changes in U.S. population distribution are likely to affect the social movement, and (4) present their findings to the class. Students were also encouraged, whenever possible, to make recommendations for action on the basis of their analysis.

Students chose topics such as the environmental movement, the formation of a woman's political party, and the white supremacy movement. They then obtained data from a variety of sources. Many contacted the headquarters of pertinent national organizations; others used the university library. The students learned to use Atlas MapMaker, a powerful cartography software package, to make demographic maps of the United States. These maps and graphs formed the basis of their in-class presentations.

In an anonymous evaluation of readings and assignments, 82 percent of students expressing an opinion endorsed the statement that they "got something out of the reading or assignment and that it should be retained if the course is taught again." Professor Newell reflects on the exercise:

> The MapMaker demographic project got students thinking geographically with a precision not possible (or at least not attained) through examination of traditional texts. The very precision of thought it called for also made it clear how much we need to introduce them to fundamental statistical reasoning, as they drew inappropriate inferences. The color displays made geographical patterns much more obvious than the standard crosshatches and the like. This novel (for them) use of the computer was motivating in itself, making otherwise distasteful numbers attractive because of their visual products.

I developed another exercise to promote student-centered discovery learning (Wolfe forthcoming) for an interdisciplinary social systems course called "Is Freedom Possible?" Introductory students were divided into seminar sections that brainstormed ideas for experiments to determine whether subliminal messages affect behavior. I used Authorware Professional and a Macintosh IIcx to implement five student-generated experiments in which students themselves served as subjects. The exercise produced enthusiasm, meaningful discussions, and increased understanding of experimentation, measurement, control, and statistics.

A year and a half later, several students were randomly selected to evaluate me as part of my third-year review. In this context, an anonymous student wrote about his or her recollection of the subliminal message experiment.

> . . . it was also very interesting and fun to take. We learned a lot from the exercise. We learned about the whole process of experimentation and using statistics in research in addition to the effectiveness of subliminal messages. Creating an actual experiment, running it, participating in it and discussing it was a far superior method of learning than simply reading about it and being lectured to.

Table 2.—Selected Exercises by Aspect of Quantitative Reasoning and Core Area

	Learning from data	Quantitative expression	Evidence and assertions	Quantitative intuition
Creativity and culture		Puritan's house		Puritan's house
Natural systems	Moon lab Frisbees	Moon lab Frisbees *Powers of Ten* Geologic time	Moon lab	Moon lab Frisbees *Powers of Ten* Geologic time
Social systems	Subliminal messages Map making	Subliminal messages Map making	Subliminal messages Map making Working poor	Working poor

The exercises and experiences described here are summarized in Table 2 by type of quantitative reasoning and core area.

Most of these exercises address more than one aspect of quantitative reasoning, although few apply to all four discussed here: learning from data, quantitative expression, evidence and assertions, and quantitative intuition.

Clearly, faculty members who approach teaching from several perspectives appreciate the need to help students develop many aspects of quantitative reasoning. A commitment to teaching in both thematic and pedagogic context is vitally important to this approach. In the humanities, natural sciences, and social sciences, we are beginning to develop quantitative reasoning experiences that are meaningful to students and serve course goals. By exposing students to quantitative reasoning in different contexts, it is hoped that the net result will be a rich and varied educational experience.

NOTES

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2. Questions and comments may be directed to the author at the School of Interdisciplinary Studies, Miami University, Oxford, Ohio, 45056, (513)529-5670, Internet:CRWOLFE @MIAVX1.ACS.MUOHIO.EDU.

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