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Spreadsheets Across the Curriculum, 1: The Idea and the Resource

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Spreadsheets Across the Curriculum, 1: The Idea and the Resource

Abstract

This paper introduces Spreadsheets Across the Curriculum, a workshop-based educational materials development project to build a resource to facilitate connecting mathematics and context in undergraduate college courses where mathematical problem solving is relevant. The central idea is “spreadsheet modules,” which, in essence, are elaborate word problems in the form of short PowerPoint presentations with embedded Excel spreadsheets. Students work through the presentations on their own, making and/or completing the spreadsheets displayed on the slides in order to perform calculations or draw graphs that address the issue (context) posed in the word problem. The end result of the project is the resource: an online library of 55 modules developed by 40 authors from 21 institutions that touch on 26 subjects as differentiated by Library of Congress classification categories. Judging from online requests for instructor versions, the SSAC Web site disseminated the SSAC module idea to an additional 60 institutions via instructors of courses with 67 different titles. The disciplinary distribution of authors and requests for instructor versions shows that the SSAC resource serves both sides of the mathematics-in-context interpretation of quantitative literacy: mathematics educators seeking ways of bringing context into their teaching of mathematics; non-mathematics educators seeking to infuse mathematics into their teaching of disciplinary subjects. The SSAC experience suggests two answers to the question: “What works to spread teaching of QL across the curriculum?”—spreadsheet exercises in which students do math to solve problems, and workshops or workshop sessions that focus on educational materials.

Keywords

spreadsheets, pedagogy

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Cover Page Footnote

Len Vacher is a professor of geology at the University of South Florida. He is a Fellow of the Geological Society of America and the 2004 recipient of the National Association of Geoscience Teachers’ Neil Miner Award. In more than 30 years of teaching, he has taught many forms of introductory geology, hydrogeology, and math concepts for geologists. His current teaching project is to build a QL course, Environmental Geology in the National Parks. He served on the charter board of the NNN and currently co-edits this journal.

Emily Lardner is co-Director of the Washington Center for Improving Undergraduate Education, a public service center based at The Evergreen State College, where she also teaches academic writing. She and Gillies Malnarich, the Center’s other co-Director, provide technical assistance to six community colleges in WA engaged in strengthening their pre-college math programs. The Washington Center is charged with improving undergraduate education in the state of Washington and beyond. It serves as a national resource center for learning communities across the curriculum.

INTRODUCTION

This paper is the first in a series on Spreadsheets Across the Curriculum (SSAC), an educational-materials development project (NSF DUE 0442629) to build a resource to facilitate student learning of mathematics in context. The purpose of this paper is to describe the resource library and its basic element, the spreadsheet module. In addition, the SSAC story told here illustrates a couple of points relevant to a goal of the NNN—finding and disseminating “what works” for the grass-roots spread of teaching quantitative literacy (QL). First, the notion of teaching with spreadsheets has wide appeal for combining mathematics and context—regardless of whether that means bringing context to math or bringing math to context. Second, workshops, such as those hosted by NNN, PKAL,¹ PREP,² and NAGT³ in this instance, can play a vital role in shaping a QL idea and turning it into an educational resource.

BACKGROUND

The Washington Center for Improving the Quality of Undergraduate Education at The Evergreen State College (TESC) was one of the four centers and programs that received funding from the National Council on Education and the Disciplines (NCED) as part of its initiative to build a national network to support education in numeracy (Madison and Steen 2008, p. 7-8). The role of the Washington Center in that NCED-era precursor to the present NNN was to “create professional development opportunities for faculty from two- and four-year colleges to learn about QL and incorporate it into the curriculum of their courses” (Madison and Steen 2008, p. 8). The SSAC project is a direct outgrowth of one of those activities: a 2003 institute on QL across the curriculum, funded jointly by the NCED grant and PREP. The goals of that workshop were to help participants develop a richer understanding of the centrality of QL in a democratic society; to integrate their work in developing QL materials with ongoing national conversations about the need to reform traditional math curricula; to become familiar with QL materials developed at a range of institutions; and to adapt and create QL materials for use on their own campuses.

The workshop attracted some 50 participants from about a dozen institutions mainly from the state of Washington. The legislators in Washington State had recently asked two- and four-year colleges to identify learning outcomes. They

¹ Project Kaleidoscope <http://www.pkal.org/> (accessed June 12, 2010).

² The Mathematics Association of America’s Professional Enhancement Program <http://www.maa.org/prep/> (accessed June 12, 2010).

³ National Association of Geoscience Teachers <http://nagt.org/index.html> (accessed June 12, 2010).

specifically asked public colleges and universities to make quantitative and symbolic reasoning one of four accountability measures. Many two-year colleges followed suit and included quantitative literacy or quantitative reasoning as one of their institution-wide learning outcomes.

Resource faculty for the workshop were drawn from the advisory group of the NCED numeracy network along with directors of the other centers. One of the representatives of the advisory group was Len Vacher, who presented an NSF project, “Spreadsheet Exercises for Geological-Mathematical Problem Solving” (DUE 126500). The purpose of that project was to create a small set of spreadsheet modules in which students would engage their mathematics while addressing a geological problem. Participants responded enthusiastically—“spreadsheet modules would work in my class!” Inspired by that response, we proceeded to write the proposal for the SSAC project. Whereas the collection of Geological-Mathematical Problem Solving modules was aimed at one course (Computational Geology, for junior- and senior-level geology majors) at one institution (USF), SSAC envisioned a library of modules for diverse courses and many institutions, albeit with a focus on the state of Washington as a germination site.

RATIONALE FOR SSAC

Even a casual browse of the QL literature in this journal and elsewhere shows that there are many flavors of numeracy. For example, there is numeracy for the needs and responsibilities of citizenship (e.g., Steen 2001); numeracy and social statistics (e.g., Best 2008; Sweet et al. 2008); numeracy to support argumentation (e.g., Lutsky 2008; Grawe and Rutz 2009); numeracy to better understand health information (e.g., Ancker and Kaufman 2007); numeracy for consumers of financial information (Huhman and McQuitty 2009); numeracy for decision making (Peters et al. 2006); numeracy for the business world (Taylor 2008).

The original Spreadsheet Exercises for Geological-Mathematical Problem Solving took a flavor that is not on that list: numeracy to enhance student learning of geology. The thinking was two-fold:

1. In performing a calculation within the context of solving a geological problem, students would learn the underlying geological concept better.
2. The students would practice the mathematics that they had already learned, thereby reinforcing it and becoming more comfortable with it and, therefore, better prepared to be geologists.

This thinking was amidst a backdrop in which many in the geoscience education community, particularly the NAGT, were working to create an environment through faculty development workshops and educational resources development

to enhance quantitative skills of geoscience majors (see Hancock and Manduca 2005; Wenner et al. 2009). At the same time, there were many in the geoscience education community making a parallel argument: geoscience educators must stop avoiding elementary mathematics (such as relationships expressed in simple equations) in introductory, service-level geology courses (Goforth and Dunbar 2000; Wagner 2000; Vacher 2001), no matter how much the students complained on students evaluations about “doing math.”

Interaction with the participants at the 2003 workshop brought the introductory, non-majors courses to the forefront. Infusing QL across the curriculum would involve a different way of thinking about the interplay of mathematics content and non-mathematics context. Whereas geological concepts (context) were given primacy in the modules developed in the original Spreadsheet Exercises for Geological-Mathematical Problem Solving project, the mathematics content would need to be primary in the new modules; the context would be what would make the mathematics worth doing from the student perspective. Further, if the goal was to be to get all students who “do not do math” to experience “doing it” in their courses beyond the walls of the mathematics building, we would be expanding into a different—more foundational—kind of mathematics.

It was not difficult in the proposal to argue the need for a project to get non-mathematics students to do math. We made the point in a preamble in the proposal.

The national news media could not contain their delight on the evening of Nov 15, 2001, after Premier Putin and President Bush met with children at Crawford Elementary School. Their delight was in the remarks that Putin and Bush interjected when the Principal, while performing the introductions, told the children that their distinguished guests had agreed to answer their questions. Putin, with an impish grin, said “So long as it’s not math.” Bush added, “No fuzzy math.” What fun, according to the nightly newscasters. Famous people don’t do math either!

SSAC takes the position that, whatever the flavor, numeracy is active, not passive. “Doing math” is a crucial part of being numerate. When confronted with a problem involving numbers, a numerate person can calculate or graph, or somehow explore the numbers. How do we get students comfortable with doing math to explore problems? SSAC answers, “Spreadsheets!”

WHY SPREADSHEETS?

In the inaugural issue of the open-access journal *Spreadsheets in Education*, editors John Baker and Steve Sugden published a review with 205 references on how spreadsheets have been used in education (Baker and Sugden 2003). To set the time frame (Power 2004; Baker and Sugden 2003): VisiCalc, which appeared in 1979, was the first electronic spreadsheet; Lotus 1-2-3 was developed in the

early 1980s and bought out VisiCalc in 1985; Microsoft Excel, which was originally written for the 512 Apple Macintosh in 1984-1985, added a graphical interface and point-and-click technology; it zoomed to prominence in 1987 when Microsoft launched its Windows operating system. As electronic spreadsheets evolved in the 1980s, papers on their educational merits began to appear in professional educational journals such as *The College Mathematical Journal* (Arganbright 1984), *Mathematics Teacher* (McDonald 1988), *Computers in Physics* (Dory 1988; Misner 1988), *School Science Review* (Elliot 1988; Brosnan 1989), *Journal of Economic Education* (Adams and Kroch 1989), *The Computing Teacher* (Parker and Widmer 1989); *Collegiate Microcomputer* (Watkins and Taylor 1989). The extent of their penetration into a discipline can be illustrated by earth science; 38 papers in the *Journal of Geoscience Education* from 1986 through 2003 incorporate spreadsheets as a teaching activity (Fratesi and Vacher 2005). Examples of contexts include two-dimensional modeling of groundwater flow (Ousey 1986), U-shaped glacial valleys (Harbor and Keattch 1995), the size of our galaxy (Shea 2003), and heat loss from a building (Frey et al. 2003).

Baker and Sugden (2003 p. 19) cite a very early paper (Hsiao 1985) that makes the obvious point about why spreadsheets would become so popular:

...while computers are clearly useful tools for education generally, one of the main disadvantages is having to program them. In many cases, (at least in 1985), students had to learn a programming language in order to benefit from computers.... Use of spreadsheets helps to get around this problem.”

The authors go on to cite many virtues of using spreadsheets educationally and assemble an extensive and impressive array of quotations. We select the following as an example;

Spreadsheets.... have a number of very significant benefits many of which should now be apparent. Firstly, they facilitate a variety of learning styles which can be characterized by the terms: open-ended, problem-oriented, constructivist, investigative, discovery oriented, active and student-centered. In addition they offer the following additional benefits: they are interactive; they give immediate feedback to changing data or formulae; they enable data, formulae and graphical output to be available on the screen at once; they give students a large measure of control and ownership over their learning; and they can solve complex problems and handle large amounts of data without any need for programming. (Baere 1993)

The references and quotations in the Baker and Sugden review—and articles in subsequent issues of *Spreadsheets in Education*—argue that teaching with spreadsheets can be a successful strategy when teaching mathematics, physics, chemistry, economics, and other quantitative, computational subjects. The context of that teaching, however, is in courses of those subjects. Students in such courses would not be characterized as math-avoidant. We do not know of studies involving students who “don’t do math.” On the other hand, when we wrote the proposal, we did know of two developments in the preceding decade

that make one think that spreadsheets would be more palatable than alternatives for getting math-avoidant students to do hands-on quantitative activities in the context of their non-quantitative, non-mathematical courses. First, spreadsheets were ubiquitous; if students owned a computer, they probably had a spreadsheet program (now, if they have an iPod, iPhone, or Blackberry they do indeed have a spreadsheet program). Second, facility with spreadsheets was becoming increasingly an expectation of employers. We suspected that peer pressure alone would convince students to get over their resistance to using a spreadsheet to do a calculation that was within their range mathematically.

	B	C	D
2	Lightning and Thunder		
	<i>The speed of light is approximately 3 hundred million meters/second. The speed of sound at sea level and at 20° C is about 1125 ft/second. You see a lightning strike 1.2 miles away. What is the time difference in seconds between seeing the flash and hearing the thunder? There are 3.281 ft in a meter and 1.609 km in a mile.</i>		
3			
4	Distance from the lightning strike to you	1.2	mi
5	-- convert distance to km	1.93	km
6	-- convert distance to meters	1931	m
7	Speed of light	300,000,000	m/sec
8	Speed of sound	1125	ft/sec
9	-- convert speed of sound to m/s	342.9	m/sec
10	Time for light to travel the distance	0.00000644	sec
11	Time for sound to travel the distance	5.6	sec
12	Difference in travel times	5.6	sec

Figure 1. Spreadsheet calculating the distance to a lightning strike.

A key part of a strategy for SSAC, then, would be to use straightforward, easy-to-follow, unintimidating spreadsheets to do a calculation. Use a spreadsheet like one would use a calculator. Lay out the steps line by line like one would on a sheet of paper. Figure 1 shows an example. The spreadsheet answers the following question: given the speed of light and the speed of sound, how long after the lightning flash does the thunder arrive if you are 1.2 miles away from the lightning strike? The spreadsheet starts (Row 4) with the distance and works through a succession of one-step calculations. First it converts the miles to kilometers (Row 5) and then meters (Row 6). Next it writes 300 million as 300,000,000 (Row 7). Then it converts the speed of sound in feet/second (Row 8) to meters/second (Row 9). Then (Row 10), it divides the distance in meters (Row 6) by the speed of light in meters/second (Row 7), and (Row 11) the distance in meters (Row 6) by the speed of sound in meters/second (Row 9) to find the travel times for the light and sound, respectively. Lastly, it finds the answer (Row 12) by subtracting the travel time for light (Row 10) from the travel time for sound (Row 11). The answer is 5.6 seconds. Students working through the calculation

would be doing unit conversions and manipulating $speed = distance/time$ to $time = distance/speed$.

Students would see immediately that the lightning flash arrives instantaneously. The travel time of the flash is negligible relative to the thunder. They could also use the spreadsheet to solve the reverse problem and experience the power of spreadsheets: once you solve the first problem, finding the answer to a similar problem is a breeze because the spreadsheet does the work. For example, how far away is the lightning strike if you count “Mississippi 1” to “Mississippi 8” between seeing the flash and hearing the thunder? Using the spreadsheet, the student can guess the distance (in miles) until the 8 appears in Cell C12 (seconds). And, then the student can manipulate the velocity equation again and use $distance = speed \times time$ to check the work with pencil and paper (and, optionally, explore significant figures).

The spreadsheet of Figure 1 can be put into context in a variety of courses. Earth science, weather, and geography are obvious examples. For people from the Tampa-Orlando corridor (the country’s statistical leader for lightning strikes), additional choices come to mind: golf; parks and recreation; journalism; Florida living; campus safety.⁴

Prompting students to step through a simple, straightforward spreadsheet such as this lightning example is the basic concept of SSAC. In essence, SSAC modules are elaborate word problems with a computational component using technology.

THE SSAC LIBRARY

The SSAC project included three annual summer institutes (2005, 2006, and 2007) in Olympia WA where faculty came for intensive one-week workshops to learn about spreadsheet modules and make a first draft of one for a class that they teach. After review, revision and editing, selected modules were posted on the SSAC Web site.⁵ The modules are housed in the General Collection⁶ of the SSAC Library. At the conclusion of the project (March 31, 2010), the General Collection included 55 modules by 40 authors from 21 institutions in 11 states (Table 1). The 55 modules are classified into 26 Library of Congress (LOC) categories ranging from BF (Psychology) to WY (nursing) (Table 2).

Modules

SSAC modules are short (ca. 15–20 slides) PowerPoint presentations that prompt students to build one or more Excel spreadsheets to solve and examine a mathe-

⁴ Richard Stessel, a popular USF engineering professor, was struck and killed by lightning while walking on campus, August 2001.

⁵ http://serc.carleton.edu/sp/ssac_home/index.html (accessed June 12, 2010).

⁶ http://serc.carleton.edu/sp/ssac_home/general/index.html (accessed June 12, 2010).

Table 1
Module Authors

State	Institution	Author	Modules
A. Mathematics faculty			
AZ	Chandler-Gilbert CC	Frank Murphy	1
IA	Buena Vista University	Nasser Dastrange	1
LA	Southern University	Lawrence Couvillion	1
		Joseph Meyinsee	1
MI	Davenport University	Gary Franchy	3
MO	Metropolitan CC - Longview	Bridget Gold	½
NH	Colby-Sawyer College	Semra Kilic-Bahi	3
NY	Alfred University	Eric Gaze	1
PA	Indiana Univ of Pennsylvania	Yu-Ju Kuo	1
WA	Central Washington Univ. The Evergreen State College	Aaron Montgomery	1
		Vauhn Foster-Grahler	1
		David McAvity	1
		Jian Zou	1
B. Non-Mathematics faculty			
CA	San Jose State University	Mike Pogodzinski	1
FL	Eckerd College University of South Florida	Laura Wetzel	1
		Dorien McGee	1
		Christina Stringer	1
		Len Vacher	5
MI	Delta College	Loretta Sharma	2
MO	Metropolitan CC - Longview Truman State University	Rebecca Foster	½
		Tony Weisstein	1
NH	Colby-Sawyer College	Maryann Allen	2
		Nicholas Baer	1
		Cheryl Coolidge	3
		Shari Goldberg	1
		Jodi Murphy	1
		Ben Steele	2
		Bill Thomas	2
		Bernadette Garam	1
NY	Manhattan College	Bernadette Garam	1
WA	The Evergreen State College	Paul Butler	2
		Rob Cole	1
		Martha Rosemeyer	1
		Rebecca Sunderman	1
	Highline CC	Eric Baer	1
	Lower Columbia College	Armando Herbelin	1
	Seattle Central CC	Michael O'Neill	2
		Ylin Sun	1
	South Seattle CC	Sara Baldwin	1
	Spokane Falls CC	Polly McMahon	1
		Rachel Wang	1

mathematical problem in non-mathematical context. The modules are intended to be problem-solving activities. In working through the modules, students work through the disciplinary problem of the context as well as the mathematics embedded in it. The immediate hands-on activity is that students need to recreate the spreadsheets. They need to figure out the cell equations to populate the

spreadsheets that apply the mathematics. Then they proceed to “end-of-module problems.”

Table 2
Number of Modules in the General Collection by Subject

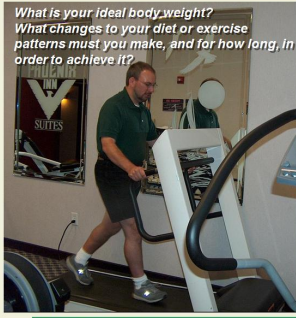
Library of Congress category		Modules
BF	Psychology	1
DT	History, Africa	1
E	History of the Americas	1
GB	Physical Geography	1
HB	Social sciences, economics, general	2
HE	Transportation and communications	1
HF	Social sciences, commerce (including accounting)	5
HG	Finance	3
HN	Social history and conditions, social problems, social reform	1
HV	Social pathology, social and public welfare. Criminology	1
JF	Political institutions and public administration	1
LB	Education, practice	2
LC	Education, social aspects	1
PN	Literature (including Star Trek)	2
Q	Science, general	1
QA	Mathematics	5
QC	Physics (including atmospheric science)	1
QD	Chemistry	5
QE	Geology	8
QH	Natural history. Biology	3
QP	Physiology	2
QR	Microbiology	2
QV	Pharmacology	1
S	Agriculture	1
TC	Hydraulic engineering	1
WY	Nursing	2

Design. The Power-Point presentations are self-contained (e.g., requiring no textbooks), and they are written for the students, not the instructors. The first slide is a title slide that includes a list of the quantitative concepts and skills that come into play in completing the module (Fig. 2). The prominence of the list aims to make it clear to the students that mathematics is a learning goal, an integral part of the activity, and that they need to take it seriously. The list can serve as a prompt to discerning students who wonder "what is going to be on the quiz?"

A typical module starts with a few slides that pose the problem and give some background on the context and relevant mathematics content. The module typically ends with a few slides of wrap-up and end-of module questions. The end-of-module assignments, which are intended as homework, commonly include

SSAC2006:QP301.LS1.2

*What is your ideal body weight?
What changes to your diet or exercise patterns must you make, and for how long, in order to achieve it?*



A Healthier You

Modeling Healthier Weight from Dietary Improvement and Exercise

Core Quantitative Issue
Forward modeling

Supporting Quantitative Issues
Algebra – rearranging an equation
Unit conversions
Rate of change
Multivariable function
Visualization – bar graph

Prepared for SSAC by
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Version 10/04/06

Figure 2. Title slide of a module

one or more questions that ask the students to change some of the parameters in the spreadsheets that they made while working through the module.

The core of the module is the sequence of slides that take the students through the construction of the spreadsheets. The spreadsheets do the calculations that address the in-context problem. In many cases, this part of the module involves graphing. The modules that are aimed at beginning spreadsheet users include Excel instructions.

Question #1 (cont.)

What do you really save in making the trip for the cheaper gas?

Initial Assumptions:

1. Our car gets 30 mpg
2. We need 15 gallons of gas
3. The cost of gas to travel to and from the cheaper gas station must be considered

Note
None of your computations required more than a single operation.

Where will you gas up now?

	B	C	D
2			
3	Fuel Efficiency	30	mi/gal
4	Number of Gallons Purchased	15	gal
5	Gas Price	\$3.00	\$/gal
6			
7	Gas Cost per Mile	\$0.10	\$/mi
8	Distance to gas station	5	mi
9	Total distance for gas station visit	10	mi
10	Cost of Visit to Gas Station	\$1.00	\$
11			
12	Savings per Gallon	\$0.10	\$/gal
13	Gross Savings	\$1.50	\$
14			
15	Net Savings (Loss)	\$0.50	\$

Formatting Hint
To display cells as dollars:
• Right click on cell
• Select "Format Cells"
• Select "Number" Tab
• Select "Currency"
• Change "Decimal Places" and/or "Negative Numbers" if desired
• Select "OK"

Figure 3. Slide 5 in "Driving across town for cheaper gas: Is it worth the effort?" by Gary Franchy.

The slides are strongly color-coded (Fig. 3). Blue text boxes contain information in the mainstream of the narrative. Green text boxes signify a "command" such as "Recreate this spreadsheet." Red text boxes give sideline information that may be interesting or useful (e.g., a hint).

The spreadsheets, which are embedded as pictures in the student version of the modules, also are strongly color-coded. For example, numbers appear in yellow and orange cells—the yellow cells contain data or known values, and the orange cells contain cell equations (Figs. 1, 3). Students use the numbers that appear in the orange cells as checks on the cell equations they have to enter into their own copy of the spreadsheet. Instructor versions, which are available by request on the SSAC Web site, are the same as the student versions except that the spreadsheets are embedded as Excel spreadsheets that can be activated to reveal the equations.

Code number. Each SSAC module has a three-part code such as SSAC2006.QP301.LS1.2 that appears on the first slide of the module (Fig. 2). The SSAC2006 segment indicates the year of the series. The SSAC2005, SSAC2006 and SSAC2007 series are from the SSAC workshops of Summer 2005, 2006, and 2007, respectively. SSAC2004 indicates modules reformatted from Spreadsheets for Geological-Mathematical Problem Solving. The second part of the code is a subject indicator following the LOC classification. The third part of the code indicates the author. LS1.2 in this case means that it is the second module produced by author LS1 (Loretta Sharma), the first SSAC author using the initials LS

Web Site

A month before the second workshop in 2006, SSAC was invited by Cathy Manduca, Director of the Science Education Resource Center (SERC) to become a partner in SERC's new Pedagogical Services project⁷ (NSF DUE 0532768). The intent of that project was to build a library of pedagogical methods together with collections of activities that exemplify them. SERC's goal was to support educators who wish to explore new teaching strategies and methods. Pedagogical Services saw SSAC as a new pedagogy "based in creative use of PowerPoint and Excel resources."⁸ In essence, SSAC was asked to contribute a Web site containing the spreadsheet modules developed at the workshops to the portal of educational resources the Pedagogical Services project was developing. In return, SSAC would use their content management system⁹ and be networked with other projects and groups who were developing new materials. That arrangement caused the creating of an SSAC Web site to be a much larger component of the project than we had anticipated, with a much more fully developed result.

The home page (Fig. 4) describes the project under three headings: The Goal, The Pedagogy, and The Library. The navigation column on the right side of the

⁷ <http://serc.carleton.edu/sp/service/index.html> (accessed June 12, 2010).

⁸ <http://serc.carleton.edu/sp/service/partners.html> (accessed June 12, 2010).

⁹ <http://serc.carleton.edu/serc/cms/index.html> (accessed June 12, 2010).

page has six links. “SSAC and Quantitative Literacy” expands on the goal of the project. “Teaching with SSAC” is a group of pages that brings SSAC into the shared design of other pedagogies in the Pedagogical Services project portal. “The SSAC Library” describes the design of the modules, the code numbers, and the cover Web pages (described below) that introduce the individual modules.



Figure 4. Screen shot of home page.

The last three links on the home page—“General Collection,” “Geology of National Parks Collection,” and “Physical Volcanology”—access the three collections composing the current SSAC Library. The General Collection is the product of the SSAC project, as discussed in this paper. The Geology of National Parks collection is being developed in a new project,¹⁰ which, in contrast to SSAC, focuses on a single course (Geology of National Parks) at a single university (USF). The Physical Volcanology collection is another special-purpose collection, this one developed by two geologists (at USF and Penn State) who got caught up in the spirit of SSAC module making and, without funding, created a collection for a new, advanced undergraduate, physical volcanology course that they were developing at their respective universities.

¹⁰ Geology of National Parks: Spreadsheets, Quantitative Literacy, and Natural Resources (NSF DUE-0826566).

General Collection. The General Collection link on the home page accesses the index page that introduces the collection.¹¹ The page lists the authors and LOC categories of the modules and includes a link to a spreadsheet version of a card catalog organized by LOC category. Most important, the index page contains the link, “SSAC General Collection Modules,” on the navigation column which accesses the browse pages¹² for the collection.

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SSAC General Collection Modules

Following are short descriptions of the available modules. To access any of them, select from the list and you will connect to cover material including learning goals, context of use, and other information. Within the cover material (under "Teaching Materials") there is a link by which you can download the student version of the module. You can also request an instructor's version by clicking on the "request" link under Teaching Materials.

There are a couple of ways of searching for modules. The box below left provides a full-text search of the cover material about the module, so you can search by author, subject, or keyword. The controlled vocabularies below right allow targeted searches by three different dimensions (click on the links to see the full, hierarchical vocabularies): [Math content \(Quantitative Concept\)](#) (Microsoft Word 41&8 Jun17 10), [Context \(Subject\)](#) (Microsoft Word 29&9 Jul13 07), and [Excel Skill](#) (Microsoft Word 22&9 Jul13 07).

search

Results 1 - 10 of 55 matches

Narrow the View

Quantitative Concepts

- Basic arithmetic: Number sense [51 matches](#)
- Measurement: Data presentation and analysis: Probability [45 matches](#)
- Algebra: Modeling: Functions [37 matches](#)
- Geometry: Trigonometry [14 matches](#)
- Calculus: Numerical methods [11 matches](#)
- Creating and manipulating tabular data [40 matches](#)

Subject

- Mathematics, statistics and computers [20 matches](#)
- Natural science [28 matches](#)
- Social science [6 matches](#)
- Library and information Science [1 match](#)
- Humanities [2 matches](#)
- Business, economics and finance [10 matches](#)
- Engineering, agriculture [2 matches](#)
- Education [3 matches](#)
- Health [5 matches](#)

Excel Skills

- Basic Arithmetic [51 matches](#)
- Angles and Trig Functions [8 matches](#)
- Other Elementary Math Functions [5 matches](#)
- Statistical Functions [7 matches](#)
- Logic Functions [6 matches](#)

Spreadsheets Across the Curriculum

Spreadsheets Across the Curriculum: The General Collection

SSAC General Collection Modules

How Large is a Ton of Rock? -- Thinking about Rock Density part of Spreadsheets Across the Curriculum General Collection Examples
Spreadsheets Across the Curriculum module. Students build spreadsheets to calculate the edge length of cubes and diameter of spheres of various rocks starting with their mineralogical composition.
Quantitative Concepts: Geometry: Trigonometry: Spheres, Cubes and rectangular solids; Algebra; Modeling: Functions: Modeling Inverse problem; Algebra; Modeling: Functions: Modeling equations; Basic arithmetic: Number sense: Ratio and proportion; percentage; Interpolation; Algebra; Modeling: Functions: Modeling Forward modeling; Basic arithmetic; Number sense: Units and Dimensions: Unit Conversions; Basic arithmetic; Number sense: Average; weighted average
Subject: Natural science: Earth science
Excel Skills: Basic Arithmetic: Nested Formulas; Angles and Trig Functions: PI; Basic Arithmetic: Simple Formulas; Arithmetic Functions: SUMPRODUCT

How Large is the Great Pyramid of Giza? -- Would it make a wall that would enclose France? part of Spreadsheets Across the Curriculum General Collection Examples
Spreadsheets Across the Curriculum module. Students calculate the volume of the Great Pyramid and, following Napoleon, estimate whether its volume is large enough to make a wall around France.
Quantitative Concepts: Geometry: Trigonometry: Cubes and rectangular solids; Other solid figures; Squares and rectangles; Basic arithmetic; Number sense: Logarithms; orders of magnitude; scientific notation; Units and Dimensions: Unit Conversions; Measurement; Data presentation and analysis; Probability: Creating equations; test-to-meet transition; Basic arithmetic; Number sense: Significant figures; Estimation
Subject: Social sciences: History; Mathematics, statistics and computers: Mathematics
Excel Skills: Basic Arithmetic: Nested Formulas; Simple Formulas

A Look at High School Dropout Rates: Average Rates of Change and Trend Lines part of Spreadsheets Across the Curriculum General Collection Examples
Spreadsheets Across the Curriculum module. Students build a spreadsheet to calculate an average rate of change and compare it to the slope of the trend line on a scatter plot of a real-world data set
Quantitative Concepts: Measurement; Data presentation and analysis; Probability: Descriptive statistics; trend lines: Line- and curve-fitting; Algebra; Modeling: Functions: Straight lines and linear functions: Slope; intercept; linear trends; Algebra; Modeling: Functions: Functions: general Concept of function; Measurement; Data presentation and analysis; Probability: Visual display of data: XY scatter plots; Basic arithmetic; Number sense: Ratio and proportion; percentage; interpolation; Rates: Rates of Change; Basic arithmetic; Number sense: Units and Dimensions; Average; weighted average
Subject: Education; Mathematics, statistics and computers
Excel Skills: Graphs and Charts: XY Scatterplot: Trendlines; One Plot; Basic Arithmetic: Simple Formulas; Arithmetic Functions: SUMPRODUCT; Basic Arithmetic: Nested

Figure 5. Screen shot of browse page for the General Collection.

The browse pages (Fig. 5) list and give a one-sentence description of each of the modules in the collection—ten to a page and in no obvious order. One can search for modules with “Narrow the View” boxes that list index terms used in the content management system to tag the modules. There are three categories for these search boxes: Quantitative Concepts; Subject; and Excel Skills. Alternatively (or additionally), one can search by author or keyword by using a search box (upper left of the browse page, Fig. 5) which activates a full-text search of the cover Web pages of the individual modules.

Cover pages. Clicking the link on the module listed on the browse page produces the cover Web page that introduces the module (Fig. 6). The format of these cover pages was prescribed by the Pedagogical Services project. To be included

¹¹ http://serc.carleton.edu/sp/ssac_home/general/index.html (accessed June 12, 2010).

¹² http://serc.carleton.edu/sp/ssac_home/general/examples.html (accessed June 12, 2010).

in the Pedagogical Services portal, a pedagogy would need a site with a title such as “Teaching with x ” (in our case, $x = \text{SSAC}$) (see home page, Fig. 4). The site would be a cascade of pages starting with “What is Teaching with x ?” and ending with “Examples”—activities illustrating the use of the x -pedagogy. These examples would be listed and indexed on one or more browse pages linking to activity sheets of a preset design (Fig. 6) describing each of the activities. In the language of SSAC, the example activities are “SSAC modules” and the activity sheets are the “cover pages.”

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FOR IMPROVING THE QUALITY OF UNDERGRADUATE EDUCATION

Administering Medications to Patients -- Calculating Dosages in the Clinical Setting

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This material is replicated on a number of sites as part of the [SERC Pedagogic Service Project](#)

Summary

In this Spreadsheets Across the Curriculum activity, students use Excel to calculate correct medication dosages. Students are first asked to think conceptually about dosage administration and then presented with a case study in which they have to determine the quantity and frequency of the dosage based on a medication order. Students also create an xy scatter plot to examine the relationship of metric units, specifically grams and milligrams.

Learning Goals

Students will:

- Gain experience in using ratios and proportions.
- Use equations and graphical interpretation to examine the relationship of units within the metric system.

In the process the students will:

- be more comfortable thinking in terms of, and working with, the metric system.
- complete simple, yet extremely important, calculations to determine correct medication dosages.

Context for Use

This module is used in my Health Assessment and Fundamentals of Nursing Course, [NUR_230](#) (Microsoft Word 127kB Dec12 06). This is an introductory class in the BSN program at Colby-Sawyer. This is a tool for students to use in preparation for the clinical calculation exam and is used before medication administration is introduced in class and lab.

Description and Teaching Materials

[SSAC206.WY100.SG1.1_Student](#) (PowerPoint 205kB Jun03 07)

The module is a PowerPoint presentation with embedded spreadsheets. If the embedded spreadsheets are not visible, save the PowerPoint file to disk and open it from there.

This PowerPoint file is the student version of the module. An instructor version in which the embedded spreadsheets can be activated (showing the cell equations) is available upon [request](#).

Spreadsheets Across the Curriculum

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SSAC General Collection Modules

Figure 6. Screen shot of cover page for SSAC206.WY100.SG1.1.

These cover pages describe the modules under seven headings formulated by Pedagogical Services project: Summary; Learning Goals; Context for Use; Description and Teaching Materials; Teaching Notes and Tips; Assessment; and References and Resources. In general, our pages were completed by the authors of the modules after they had made their module and before they had used it in class, and so only the first three sections contain much information. The summary describes what the students do in the activity and the context and quantitative content that the module covers. Learning Goals describe what the

author intends for the students to experience and get out of the activity. Context for Use identifies the course for which the module is prepared.

The Teaching Materials section contains the link to the particular module. The short section includes a statement that the online module is the student version and that instructor versions are available by request. The main difference between student and instructor versions is in how the spreadsheets are embedded—as pictures in student versions so that the cell equations do not show, or as Excel worksheets in instructor versions so that the cell equations are accessible. Instructor versions of the SSAC2006 and SSAC2007 series also have a short quiz that was prepared by the authors for pre- and post-module assessment.

Who's Asking?

The Teaching Materials section of the cover page includes a link to an online form to request the instructor version of the module. The request form asks for the requester's name, contact information, institution, and department. It also asks for information about the course in which the module may be used: the number and title of the course, number of students, a brief description, and how the module will be used.

From mid-October 2006 to mid-October 2009, SSAC received 121 requests for instructor versions of modules in the General Collection (Fig 7). The requests came from 72 different people from 26 states in the US as well as 12 other countries. Forty-two (76%) of the 55 modules in the General Collection were requested at least once.

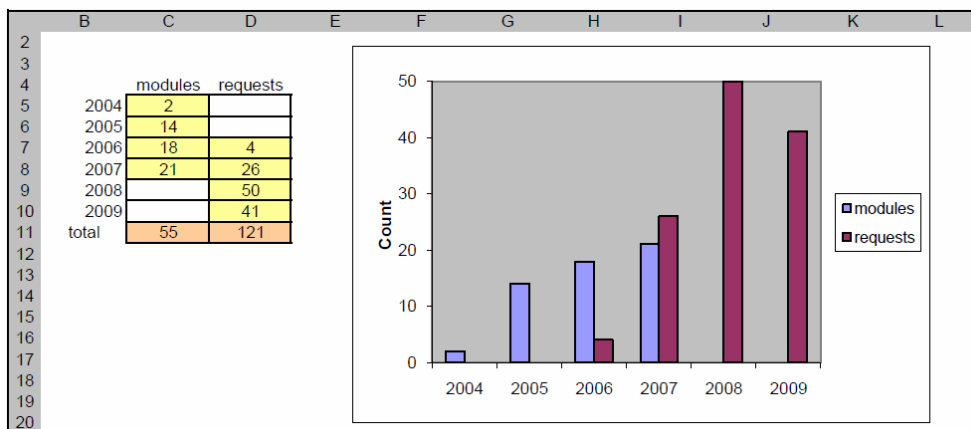


Figure 7. Spreadsheet listing and graphing the number of modules produced and requests for instructor versions by year through mid-Oct, 2009.

Table 3A
Mathematics Courses Identified in Requests for Instructor Versions of
SSAC Modules

Type of Institution	Course	Students	Modules
University	Calculus (Laboratory)	20	2
	Math Reasoning	90	1
	In-service for Teachers (math)	20	1
College	College Algebra	20	3
	Quantitative Literacy	100	1
Two-Year College	College Algebra	60	2
	Elementary Algebra	40	1
	Elementary Algebra	25	1
Secondary Schools	Basic Math Concepts	75	6
	Geometry (including Trigonometry)	125	1
	Consumer Math	20	1
	Statistics	10	1
	Computer Math	74	1
	8 th Grade Mathematics	120	1
Community (Adult) School	Community Math	60	1
	Community Math	20	1

The vast majority (108 or 89%) of the requests were associated with specific courses at specific institutions (Tables 3A and 3B). In all there were 64 institutions. They break down into categories as follows:

- Universities: 28, including 19 in the US, and one each in Canada, Jamaica, El Salvador, Venezuela, Peru, Sweden, Italy, The Slovak Republic and Sudan.
- Colleges: 12, all in the US.
- Two-Year Colleges: nine, all in the US.
- High School: 11, nine in the US, one in Portugal, one in Thailand.
- Boarding School: one in Australia.
- Community Schools (adult education): two in the US.

Only four of the 64 institutions of Tables 3A and B overlap with the 21 institutions of the module authors (Table 1): one university (USF), two colleges (Colby-Sawyer; Evergreen) and one TYC (Spokane Falls). Therefore, modules of the General Collection were produced and/or requested by individuals from 81 institutions, meaning that the partnership of SSAC within the Pedagogical Services project increased the known reach of the SSAC project by some 286% (from 21 institutions to 81) as of October 2009.

The 108 requests in Tables 3A and B are for a total of 67 courses. Taking account of duplicates (two courses each in Environmental Geology, Macroeconomics, College Algebra, Elementary Algebra, and Community Math), there are 62 different titles. Thirteen (21%) of these titles are math courses in

Table 3B
Non-Mathematics Courses Identified in Requests for Instructor Versions
of SSAC Modules

Type of Institution	Course	Students	Modules
University	Systems Analysis	40	13
	World Agriculture	170	4
	Administration Science	20	3
	Introductory Geology (seismology)	15	2
	Karst Geology	8	2
	Introduction to College	37	1
	Introduction to Engineering	70	1
	Introduction to Computers	60	1
	Numerical Tools (engineering)	40	1
	Statistics (economics)	30	1
	Physics	18	1
	Mechanics	12	1
	Chemical Engineering	25	1
	Radiation Biology	50	1
	Agroecology	50	1
	Plant Ecology	55	1
	Physical Geology	40	1
	Planet Earth	10	1
	Earth Resources	32	1
	Volcanoes and Earthquakes	72	1
	Environmental Geology	100	1
	Environmental Geology	30	1
	Geomorphology	25	1
Seismology	8	1	
Math Applications for Earth Science	10	1	
Economics	20	1	
College	Historical Geology	20	7
	Earth Systems	18	3
	Climate Change	13	2
	Landscape Processes	50	2
	First-Year Seminar	18	1
	Educational Technology	22	1
	Introductory Biology	65	1
	Genetics	24	1
	Macroeconomics	45	1
	Macroeconomics	20	1
Honors (non-math)	28	1	
Two-Year College	Excel Basics	18	1
	Introduction to Natural Resources	32	1
	Earth Science	150	1
	Microeconomics	40	1
	Nursing	100	1
Human Services	25	1	
Secondary Schools	Personal Finance	25	3
	Geology	25	2
	Chemistry	15	1
	Introduction to Business	150	1
	Record Keeping	20	1
	Accounting	20	1
	Professional Development	100	1
Boarding School	Health Studies	21	1

mathematics departments (Table 3A). The other 49 courses are distributed across the curriculum (Table 3B), as was the intent of the project. Many (15) of the non-mathematics courses are geology courses, reflecting the geoscience-education heritage of SERC and its continuing workshops and other activities in that arena (e.g., Wenner et al. 2009).

The 67 courses of Tables 3A and B reach a total of 2,988 students. Those students are fairly evenly distributed between (1) universities and colleges (1618 students or 54% of the total) and (2) the others, namely, two-year colleges and secondary and community schools (1370 students or 46%) (Table 4).

Table 4.
Distribution of Students in Courses for Which Instructor Versions of SSAC Modules Were Requested (10/2006-10/2009)

Type of Institution	Math courses	Non-math courses	Totals
TYC, HS, community schools	629	741	1370
Universities and four-year colleges	250	1368	1618
Totals	879	2109	2988

Table 4 shows how the numbers of students split between math courses and non-math courses. The 13 math titles (21% of the 62 titles) have 879 of the 2988 total students (29%), reflecting more students per math title (68) than non-math title (43). More interesting is the uneven split of the two types of courses with respect to the two categories of institution (Table 4): the 879 students in the math courses are mostly (72%) in two-year colleges and secondary and community schools, and the 2109 students in the non-mathematics courses are mostly (64%) in the universities and four-year colleges. Thus, although SSAC modules obviously have appeal both to instructors interested in bringing context to their mathematics courses and instructors interested in bringing mathematics to their context courses, in terms of numbers of students reached, the potential impact of the first (mathematics courses with context) appears to be higher in high schools and two-year colleges than in universities and four-year colleges, whereas the potential impact of the second (context courses with mathematics) appears to be higher in universities and four-year colleges than in high schools and two-year colleges.

In addition to the requests associated with specific institutions and courses, SSAC has received numerous and diverse requests that we characterize as “none of the above.” These include:

- An elementary school teacher interested in self-education.
- A young wife interested in home schooling her children and helping her husband prepare for a GED.

- A mother of an elementary school child researching Excel ideas in collaboration with her child's teacher.
- A TYC faculty member getting ideas for using Blackboard.
- A high school math coordinator for a school district investigating classroom resources.
- A research evaluator for another school district doing the same for a course in data analysis.
- A university Center for Education Research preparing for a teacher workshop.
- A project evaluator for another NSF-supported QL project.

This diversity shows the potential broad appeal of spreadsheet modules—even beyond the classroom.

Reflections

The subtitle of this journal is “Advancing Education in Quantitative Literacy.” In that regard, what works? The SSAC experience suggests that we can put two items on the list: spreadsheet exercises in which students do math to solve problems, and workshops or workshop sessions that focus on educational materials.

Spreadsheets

Spreadsheets offer a readily accessible cross-disciplinary platform for dissemination of numeracy. The appeal of modules that prompt students to build spreadsheets to solve problems was apparent throughout the project. At the Washington Center's 2003 Institute on QL across the curriculum, the enthusiasm of the participants for spreadsheet modules developed in the phase-1 project (one course, one institution) led directly to the proposal for the phase-2 SSAC project to develop modules conjoining math and context in courses across the curriculum. The 55 modules created in the project are cataloged into 26 different Library of Congress categories—and were created by 13 mathematics faculty and 27 non-mathematics faculty from 21 different institutions. Among the visitors to the online library housing the modules, 72 went to the trouble of filling out a form to request instructor versions of one or more modules. Sixty of those were from institutions not represented by the module authors. The requests indicated that the modules were considered for at least 62 different courses (different titles)—13 math courses and 49 non-mathematics courses. Whether the goal is to bring context to mathematics courses or to bring mathematics to non-mathematics courses, the SSAC experience shows that educators are interested in materials that have students using spreadsheets to do math.

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References

- Adams, F. G. and E. Kroch, 1989. The computer in the teaching of macroeconomics. *Journal of Economic Education* 20(3): 269–280.
- Ancker, J.S. and D. Kaufman. 2007. Rethinking health numeracy: A multidisciplinary literature review. *Journal American Medical Information Association* 14(6): 713–721.
- Arganbright, D. 1984. The electronic spreadsheet and mathematical algorithms. *The College Mathematics Journal* 15: 148–157.
- Baker, J.E. and S.J. Sugden. 2003. Spreadsheets in education – The first 25 years. *Journal of Spreadsheets in Education* 1(1): 18–43.
- Beare, R. 1992. Software tools in science classrooms. *Journal of Computer Assisted Learning* 8: 221–230.
- 1993. How spreadsheets can aid a variety of mathematical learning activities from primary to tertiary level. In *Technology in Mathematics Teaching: A Bridge Between Teaching and Learning*, ed. B. Jaworksi. 117–124. Birmingham U.K.: University of Birmingham.
- Best, J. 2008. Beyond calculation: Quantitative literacy and critical thinking about public issues. In *Calculation vs. Context*, ed. B.L. Madison and L. A. Steen, 125–135. Washington DC: Mathematics Association of America. <http://www.maa.org/QI/calcvcontext.html> (accessed June 22, 2010)
- Brosnan, T., 1989. Teaching chemistry using spreadsheets – I: Equilibrium thermodynamics. *School Science Review* 70: 39–47.
- Dory, R.A., 1988. Spreadsheets for physics. *Computers in Physics* 2(3): 70–74.
- Elliot, C., 1988. Spreadsheets in science teaching. *School Science Review* 70: 87–93.
- Fratesi, Sarah E., and H.L. Vacher. 2005. Using Spreadsheets in Geoscience Education: Survey and Annotated Bibliography of Articles in the Journal of Geoscience Education through 2003. *Spreadsheets in Education* 1 (3): 190–216: <http://epublications.bond.edu.au/ejsie/vol1/iss3/3> (accessed June 22, 2010).
- Frey, S. T., W.R. Moomaw, J.A. Halstead, C.W. Robinson, K.A. Marsella, and J.J. Thomas. 2003. Home energy conservation exercise. *Journal of Geoscience Education* 51(5): 521–526.

- Goforth, T.T. and J.A. Dunbar. 2000, Student response to quantitative aspects of instruction in an introductory geology course. *Mathematical Geology* 32: 187–202.
- Grawe, Nathan D. and Carol A. Rutz. 2009. Integration with writing programs: A strategy for quantitative reasoning programming development. *Numeracy* 2(2): Article 2. <http://dx.doi.org/10.5038/1936-4660.2.2.2> (accessed June 22, 2010).
- Harbor, J.M. and S.E. Keattch. 1995. An undergraduate laboratory exercise introducing form-development modeling in glacial geomorphology. *Journal of Geoscience Education* 43(5): 529-533.
- Hancock, G., and C. Manduca. 2005. Developing quantitative skills activities for geoscience students. *Eos, Transactions of the American Geophysical Union*: 86(39), <http://dx.doi.org/10.1029/2005EO390003>.
- Hsiao, F.S.T., 1985. Micros in mathematics education – Uses of spreadsheets in CAL. *International Journal of Mathematical Education in Science and Technology* 16(6): 705–713.
- Huhmann, Bruce A. and S. McQuitty. 2009. A model of consumer financial numeracy. *International Journal of Bank Marketing* 27(4): 270–293.
- Lutsky, N., 2008, Arguing with numbers: Teaching quantitative reasoning through argument and writing. In *Calculation vs. Context*, p. 59–74.
- Madison, Bernard L. and Lynn Arthur Steen. 2008. Evolution of numeracy and the National Numeracy Network. *Numeracy* 1(1), Article 2. <http://dx.doi.org/10.5038/1936-4660.1.1.2> (accessed June 22, 2010).
- McDonald, J. 1988. Integrating spreadsheets into the mathematics classroom. *Mathematics Teacher* 81(8): 615–620.
- Misner, C. W., 1988. Spreadsheets tackle physics problems. *Computers in Physics* 2(3): 37–41.
- Ousey, J.R., Jr. 1986. Modeling steady-state groundwater flow using microcomputer spreadsheets. *Journal of Geoscience Education* 34(5): 305–311.
- Parker, J. and C. Widmer 1989. Using spreadsheets to encourage critical thinking. *The Computer Teacher*: 27–28.
- Peters, E., D. Vastfjall, P. Slovic, C.K. Mertz, K. Mazzocco, and S. Dickert. 2006. Numeracy and decision making. *Psychological Science*, 17(5): 410–413.
- Power, D.J., 2004. *A Brief History of Spreadsheets*. <http://dssresources.com/history/sshistory.html> (accessed June 22, 2010).
- Relf, S., and Almeda, D. (1999), Exploring the birthdays problem and some its variants through computer simulation. *International Journal of Mathematical Education in Science and Technology* 30: 81–91.
- Shea, J.H. 1993. An exercise for introductory earth science classes on using globular clusters to determine the size of the Milky Way and our position in

- it. *Journal of Geoscience Education* 41(5): 490–496.
- Steen, Lynn Arthur, ed. 2001. *Mathematics and Democracy: The case for Quantitative Literacy*. Washington, DC: Woodrow Wilson National Fellowship Foundation.
<http://www.maa.org/ql/mathanddemocracy.html>
- Stephen Sweet, Susanne Morgan, and Danette Ifert Johnson, 2008. Using local data to advance quantitative literacy. *Numeracy* 1(2): Article 4.
<http://dx.doi.org/10.5038/1936-4660.1.2.4> (accessed June 22, 2010)
- Taylor, C. 2008. Preparing students for the business of the real (and highly quantitative) world. In *Calculation vs. Context*, ed. B.L. Madison and L. A. Steen, 109–124. Washington DC: Mathematics Association of America.
<http://www.maa.org/QI/calcvcontext.html> (accessed June 22, 2010).
- Vacher, H.L. 2001, Better math, better geology: *Geotimes* 46(3): 13, 31.
- Wagner, J.R. 2000. Sneaking mathematical concepts through the back door of the introductory geology classroom. *Mathematical Geology* 32: 217–229.
- Watkins, W. and M. Taylor 1989. A spreadsheet in the mathematics classroom. *Collegiate Microcomputer* 7(3): 233–239.
- Wenner, Jennifer M., Eric M. Baer, Cathryn A. Manduca, R. Heather Macdonald, Samuel Patterson, and Mary Savina. 2009. The Case for Infusing Quantitative Literacy into Introductory Geoscience Courses. *Numeracy* 2(1), Article 4. <http://dx.doi.org/10.5038/1936-4660.2.1.4> (accessed June 22, 2010).