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Spreadsheets Across the Curriculum, 2: Assessing Our Success with Students at Eckerd College

Laura Reiser Wetzel
Eckerd College, wetzellr@eckerd.edu

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Abstract
The Spreadsheets Across the Curriculum (SSAC) library consists of activities to reinforce or teach quantitative literacy or mathematical concepts and skills in context. Each SSAC "module" consists of a PowerPoint presentation with embedded Excel spreadsheets. Each student works through a presentation, thinks about the in-context problem, figures out how to solve it mathematically, and builds spreadsheets to calculate and examine answers.

To assess the effectiveness of SSAC modules, I surveyed Eckerd College undergraduates in two separate studies. Two undergraduate research assistants and I generated pre- and post-tests for 10 SSAC modules. We hired 21 undergraduates who conducted 62 individual module assessments during their free time in exchange for modest stipends. To complement this initial study, 12 students assessed three modules in the context of an upper-level geology course. In both the individual and in class experiments, students with a wide variety of academic interests and expertise showed improvements in quantitative and Excel skills.

Based on my experiences, I recommend that instructors wishing to use SSAC modules carefully match student ability with module difficulty, use more than one module over the course of a semester, ensure that students have realistic expectations before starting, and facilitate student use in a supervised setting.

Keywords
quantitative literacy, spreadsheets, assessment

Cover Page Footnote
Laura Reiser Wetzel is Associate Professor of Marine Science and Chair of the Natural Sciences Division at Eckerd College. She received the College's Distinguished Teacher Award in 2007 for her geoscience and general education courses. Her research area is earthquake seismology.

Introduction

The on-line *Spreadsheets Across the Curriculum* (SSAC) library consists of activities to reinforce or teach quantitative literacy (QL) or mathematical concepts and skills in context[1] (Vacher and Lardner 2010). Each activity (called a "module" in the SSAC project) consists of a PowerPoint presentation with embedded Excel spreadsheets. Each student works through a presentation, thinks about the in-context problem, figures out how to solve it mathematically, and builds spreadsheets to calculate and examine answers. SSAC modules were created by faculty from all over the United States in various disciplines (e.g., natural sciences, mathematics, social sciences, nursing) and are freely available at the on-line Science Education Resource Center (SERC) searchable by quantitative skill, subject area, and Excel level.[2] Quantitative concepts contained within the modules include, for example, basic arithmetic, ratio and proportion, data presentation and analysis, algebra, and modeling (Vacher and Lardner 2011).

The objectives of the individual and in-class experiments reported here were three-fold: (1) to determine whether students improve their quantitative and Excel skills as well as gain subject knowledge in the process of completing SSAC modules; (2) to provide recommendations to help educators use SSAC modules more effectively in their classes; and (3) to conduct a formative study to gain insights into SSAC module assessment, including information on testing and interview formats as well as questions for survey instruments.

These objectives were addressed in two related studies. First, undergraduate students at Eckerd College were hired to use and evaluate SSAC modules. Twenty-one students with diverse majors worked individually to complete pre- and post-tests as well as personal interviews to gauge their familiarity with and attitudes toward using Excel and mathematics. Following that study, 12 students in Earth Structure, an upper-level geology course within the Marine Science major, assessed three SSAC modules within the context of the course. Overall, students in both the individual and in-class studies showed improvements in quantitative and Excel skills, as well as gained knowledge of the module's subject matter (e.g., economics, geology, forensic science, etc.).

Background

Eckerd is a private liberal arts college located in St. Petersburg, Florida, with a student body of ~1,800 full-time undergraduates in 38 degree programs. In 2004

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[1] http://serc.carleton.edu/sp/ssac_home/index.html: home page of the Spreadsheets Across the Curriculum project.
[2] http://serc.carleton.edu/sp/ssac_home/general/examples.html: search page for the General Collection of the SSAC Library.

I began using PowerPoint modules with embedded Excel spreadsheets to teach my Introduction to Marine Science, Earth Materials, Earth Structure, and Solid Earth Geophysics courses offered in Eckerd's Marine Science major. SSAC modules have been particularly valuable to me in teaching Excel skills and quantitative aspects of geosciences. Ultimately, I would like my students to interpret and validate quantitative results from the scientific literature; apply quantitative methods to solve new scientific problems; and communicate quantitative scientific concepts to others. In short, I would like my students to be quantitatively literate, especially for scientific contexts.

The case for quantitative literacy has been made repeatedly (Gal 1997; Steen 1997, 2001, 2004; Richardson and McCallum 2003; Madison and Steen 2003). Many authors have described QL efforts across the curriculum, beyond formal mathematics courses (Hughes-Hallett 2001; Steele and Kiliç-Bahi 2008; Sweet et al. 2008; Wenner et al. 2009; Bressoud 2009). Furthermore, numerous authors have advocated using technology, such as spreadsheets, to develop students' math skills (Jacobson and Kozma 2000; Jiang and McClintock 2000; Ozgun-Koca 2001; Baker and Sugden 2003; Alagic 2003; Abramovich et al. 2010). And, particularly in recent years, instructors have developed assessment instruments and reported results for a variety of QL and quantitative reasoning efforts (Korey, 2000; Taylor 2009; Wallace et al. 2009). I present here the results of a modest assessment effort to determine the effectiveness of SSAC modules, which constitute a set of teaching tools that use spreadsheets to develop the QL of undergraduate students outside of the context of formal math classes.

Materials

SSAC modules were created by a community of educators, most of whom met for one-week "module-making workshops" in Olympia, Washington, in July of 2005, 2006, and 2007. Educators designed modules at the workshops both to use in their own classrooms and to make available for others to adopt and adapt at other locations and in other classes.

From the SSAC General Collection, I chose 10 modules for students with a wide range of interests, Excel skills, and quantitative literacy levels (Table 1). Based on our assessments of the difficulty level for the combination of quantitative concepts and required Excel skills, we divided the modules into three groups: beginner, intermediate, and advanced.

In the module *Is It Hot in Here? Spreadsheeting conversions in the English and Metric Systems* by C. Coolidge, students perform calculations with various units for temperature, volume, and mass (Coolidge 2006). This module is for beginners as it provides extensive step-by-step instructions for students to calculate unit conversions and use Excel. It is particularly appropriate for science students but can be used with nearly any undergraduate audience.

Table 1
SSAC Modules Assessed by Students in the Individual Experiment

Level	*N*	Module Title	Module Author	Author's Institution	Core Quantitative Skills
Beginner	8	*Is It Hot in Here?*	Cheryl Coolidge	Colby-Sawyer College	Number sense: Unit conversions
	8	*Driving Across Town for Cheaper Gas: A Cost/Benefit Analysis*	Gary Franchy	Davenport University	Mathematical modeling
	8	***Vacation! How Long and How Far?***	**Judy McIlrath**	**University of South Florida**	**Basic math**
	7	*Index Numbers: Gasoline and Inflation*	Semra Kiliç-Bahi	Colby-Sawyer College	Percentages
Intermediate	8	*Illegal Software Installation*	Maryann Allen	Colby-Sawyer College	Data presentation
	8	*What Time Did the Potato Die?*	Rebecca Sunderman	Evergreen State College	Graphing
	5	*How Large is the Great Pyramid of Giza?*	H. L. Vacher	University of South Florida	Estimation
	4	***Earthquake Magnitude***	**Laura Wetzel**	**Eckerd College**	**Orders of magnitude & logarithmic scales**
Advanced	4	*Global Climate*	Paul Butler	Evergreen State College	Estimation
	2	***Frequency of Large Earthquakes***	**H. L. Vacher**	**University of South Florida**	**Data analysis: Exploratory statistical descriptors**

Note: *N* here is the number of students who evaluated the module in the individual study. Twelve students in a classroom setting also tested the modules that are in bold.

Driving Across Town for Cheaper Gas: A Cost/Benefit Analysis by G. Franchy, another module for beginners, focuses on simple mathematical modeling (Franchy 2006). Students start with calculating the cost of gas consumed while driving, encountering concepts such as miles per gallon and cost per mile. They eventually incorporate other factors in their calculations such as travel time and wear and tear on a vehicle.

Vacation! How Long and How Far? A Geological Circuit of National Parks in the Colorado Plateau by J. McIlrath is a virtual field trip where students establish a budget and time line to drive through 14 parks in the western U.S. (McIlrath 2009[3]). This is also a beginner-level activity and is particularly interesting to geology students as the module provides hyperlinks for geological information about each park

In the module *Index Numbers: Gasoline and Inflation* by S. Kiliç-Bahi, students determine whether or not gasoline prices are really higher "now" (2005) than they were in the past (Kiliç-Bahi 2005). They calculate and graph the actual and relative costs of gasoline over a 27-year period, constructing a gasoline index

[3] Originally published in the General Collection of the SSAC Library by J. Harden in 2006, but moved in 2009 to the Geology of National Parks Collection as J. McIlrath.

number and using the consumer price index. This is also a module for beginners, but is slightly more challenging than the activities by Coolidge, Franchy, and McIlrath.

Illegal Software Installation: Tracking Software Piracy Rates Around the World by M. Allen is an intermediate-level module where students calculate piracy losses in terms of absolute dollars and rates (Allen 2006). It is particularly effective in teaching students how to manipulate pivot tables and create pivot charts in Excel.

In the module *What Time Did the Potato Die?* by R. Sunderman, students determine a crime victim's time of death using body temperature versus time data (Sunderman 2005). In this case, the "body" is a potato and the "time of death" is when the potato came out of the microwave. Students use Excel's Chart Wizard extensively in this intermediate-level activity, making graphs, adding trend lines, and interpreting linear as well as exponential curves.

In the module *How Large is the Great Pyramid of Giza?* by H. L. Vacher, students investigate Napoleon's estimate that there is enough stone in the pyramid to build a wall around France (Vacher 2006a). Students perform unit conversions, learn the concept of significant figures, and calculate the volume of a pyramid as well as the cross-sectional area of a wall in this intermediate-level activity.

Earthquake Magnitude: How Can We Compare the Sizes of Earthquakes? by L. Wetzel is an intermediate-level module where students explore logarithms by calculating ratios, rearranging equations, and creating semi-log and linear graphs (Wetzel 2005). At the end of the module students apply their general knowledge of the earthquake magnitude scale to compare specific disasters, such as the 1906 San Francisco and 2004 Sumatra earthquakes.

In the advanced module *Global Climate: Estimating How Much Sea Level Changes when Continental Ice Sheets Form* by P. Butler, students estimate the volume of Earth's oceans to determine sea levels during the last ice age (Butler 2006). After completing the module, students predict the rise in sea level if all of the Earth's ice melts.

In another advanced module, *Frequency of Large Earthquakes – Introducing Some Elementary Statistical Descriptors* by H. L. Vacher, students explore statistical concepts, including mean, variance, percentiles, and normal distributions (Vacher 2006b). Students use a wide range of statistical functions and graph their results in Excel.

Methods

SSAC modules were tested in two distinct settings. In the first experiment, 21 Eckerd College undergraduates (5 men and 16 women) were recruited to test modules individually during the summer of 2007. Students volunteered from a variety of majors, consisting of two from the humanities, six from the behavioral sciences, and 13 from the natural sciences. In the second experiment, 12 Marine Science majors in Earth Structure, a 300-level course, tested modules while taking the class in the fall of 2007. In the first experiment, students completed one to six modules outside the context of a course and without any lectures on module content. In the second experiment, students completed three modules within the context of a course with lectures on module content, including some reviews of quantitative concepts. To distinguish the different situations, I refer to these as the "individual" and "in-class" experiments.

Individual Experiment

I recruited two Eckerd College juniors to assist me: Courtney Kniss, an Environmental Studies major and Geology minor, and Peter Whicker, a Marine Science major specializing in Biology. They worked full time for eight to ten weeks during the summer, helping to develop surveys, assist student testers, and record survey results. They began by reviewing the collection of SSAC modules available at the on-line Science Education Resource Center to select a subset for our study. At the time of our initial study (summer 2007) no assessment questions had been posted on the SSAC site, so, after selecting 10 modules, we constructed pre- and post-tests consisting of multiple-choice and open-ended questions to assess student attitudes toward math and Excel, basic Excel skills, quantitative literacy, and content knowledge. We created a series of "core" questions that were the same for each test, complemented by a set of questions to target concepts addressed in individual modules. (The Supplemental File contains select pre- and post-test questions.)

We recruited 21 Eckerd College undergraduates who completed a total of 62 module assessments in exchange for modest stipends. We interviewed each student before they started testing modules and after they had completed their experience. Students tested modules during three-hour self-paced sessions on weekday evenings in a PC computer lab on the Eckerd College campus. We encouraged students to ask questions of each other as well as the proctors while they worked on their own individual modules. Students used Excel 2003 and were provided with a help sheet containing basic Excel operators such as addition, subtraction, and exponents, as well as information on absolute cell references. Before their first module, students were also given a sheet delineating expectations for module assessment. Among other things, students were cautioned that they should expect to be challenged, as the modules do not necessarily step them through every equation or click of the mouse in Excel. Students attempted a pre-test just before starting and took a post-test immediately after completing each module (Table 2). They were not allowed to use the Excel help sheet, a calculator, or computer for the pre- and post-tests. Students were allowed to use these resources for a one-page open-ended survey where we asked them to comment on specific parts of the modules they would recommend changing. (See the Supplemental File for select "End Survey Questions.")

Table 2
Order of Events for Students in the Individual Experiment

Before 1st Module	**After 1st Module**
1) Personal Interview	1) General End Survey Questions
2) Expectations explained in writing	2) 1st Module Post-Test
3) 1st Module Pre-Test	3) Student decides whether to continue
Before 2nd Module	**After 2nd Module**
2nd Module Pre-Test	1) General End Survey Questions
(Student may stop after any number of	2) 2nd Module Post-Test
SSAC modules or complete up to six.)	3) Student decides whether to continue
After Last Module	
Complete Exit Interview with C. Kniss, P. Whicker, or L. Wetzel, and sign employment forms to receive stipend payment.	

All students started with one of the beginner modules, progressing to more difficult levels as we deemed appropriate. If a student worked through a module quickly and seemed confident of his or her Excel skills, the next module would be at a higher level. If a student struggled with the module, then he or she would be given another module at the same level. Individual students completed from one to six modules over the course of the summer. Students were required to complete all spreadsheets in the modules, including the "End of Module" questions. As they finished modules, students submitted all electronic files to a proctor.

Of the 21 Eckerd College students who participated in the individual study, four students completed six modules, three completed four modules, four completed three modules, four completed two modules, and six completed one module for a total of 62 completed modules. Students ranged in level from rising sophomores to individuals who graduated a month before beginning the study.

In-Class Experiment

As part of the Earth Structure course at Eckerd College in the fall of 2007, twelve students completed three SSAC modules. All were Marine Science majors specializing in geology or geophysics, ranging from sophomores to seniors. The students progressed from the beginner level (*Vacation!* by McIlrath), through intermediate (*Earthquake Magnitude* by Wetzel) to advanced (*Earthquake Frequency* by Vacher). McIlrath's module was chosen because it introduces students to the SSAC module format in a geologic context. Wetzel's and Vacher's earthquake modules where used because all students were writing a term paper about a historically significant earthquake. Hence, all three modules related to the context of the course and developed appropriate quantitative concepts.

Before starting the modules, students were provided with the basic Excel help sheet and the document outlining expectations. In addition to completing the same pre- and post-test questions posed to individual summer students, students in the class also attempted additional open-ended questions assessing quantitative concepts from McIlrath's and Vacher's modules. (These questions are included at the end of the Supplemental File and are also available to all educators who request the instructor's versions of the SSAC modules on-line at the SERC Web site.) In each case, students were allowed to use calculators for these additional questions. Students completed the pre- and post-tests in-class within a week before each module and after completing the last module (Table 3). Hence, I have four sets of results for each student.

Table 3
Order of Events for Students in the In-Class Experiment

Before 1st Module
Expectations explained in writing; *Vacation!* Module Pre-Test and Additional QL Questions
Before 2nd Module
Vacation! Module Post-Test and Additional QL Questions combined with *Earthquake Magnitude* Module Pre-Test
Before 3rd Module
Earthquake Magnitude Module Post-Test combined with *Earthquake Frequency* Module Pre-Test and Additional QL Questions
After 3rd Module
Earthquake Frequency Module Post-Test and Additional QL Questions

For the first module, all students spent a one-hour Friday class period working either alone or in pairs on laptops. They were allowed to talk amongst themselves and ask questions of the instructor. They were then given the option to complete the module on their own over the weekend or to return to class on Monday to complete their work. For their second experience, I gave a short review of logarithms several days before we were scheduled to work on the earthquake magnitude module in-class. For both their second and third modules, I provided students with the address of the SERC Web site in case some wanted to download the modules and start early. Several students chose to complete the earthquake magnitude and frequency modules entirely on their own while others joined me for two one-hour class periods to work on the activities where they could obtain help from the instructor.

Results

Some of our survey questions asked students to reflect on how they felt about whether or not the modules helped them learn. Students were asked to select one of five answers: strongly agree, agree, neutral, disagree, or strongly disagree. To succinctly present these data, average student responses to select questions are presented in Table 4. A score of five corresponds to "strongly agree" and as a result the closer the average score is to five, the more positive the student opinions.

Table 4
Average Student Responses after Each Module

	Post 1	Post 2	Post 3	Post 4	Post 5	Post 6
Q: I can use a spreadsheet comfortably to create graphs.						
Individual	3.62	3.80	4.18	4.00	4.00	3.75
In Class	3.58	4.00	4.25			
Q2: This module made me more comfortable with using spreadsheets.						
Individual	3.86	3.47	3.82	3.86	4.25	4.50
In Class	3.83	4.00	3.67			
Q3: This module improved my Excel skills.						
Individual	3.81	3.60	4.00	3.57	4.00	4.00
In Class	3.58	3.91	3.67			
Q4: This module improved my math skills.						
Individual	2.67	3.00	3.82	3.14	3.75	4.25
In Class	3.00	3.27	3.00			
Q5: This module improved my understanding of ... (module specific content)						
Individual	3.55	3.93	4.09	3.71	4.50	4.25
In Class	3.42	3.73	3.33			
Q6: This module was interesting.						
Individual	3.14	3.53	4.00	3.86	4.25	4.25
In Class	3.58	3.55	3.25			
Q7: I would recommend using this module in college level courses.						
Individual	3.48	3.67	3.64	4.14	4.50	4.25
In Class	3.75	3.91	3.50			
Number of Student Responses						
Individual	21	15	11	7	4	4
In Class	12	11	12			

Note: Higher averages indicate more positive student responses: 5=strongly agree; 4=agree; 3=neutral; 2=disagree; 1=strongly disagree

For example, after completing one SSAC module, most of the 21 students who completed modules on an individual basis gained confidence in their abilities to perform calculations with Excel as reflected by an average score of 3.81 in response to the statement, "This module improved my Excel skills" (Table 4, Question 3). Overall, students became more at ease with spreadsheets as they completed more modules, with scores in response to the statement, "This module made me more comfortable with using spreadsheets," increasing from 3.86 after completing one module to 4.50 after completing six modules (Table 4, Q2). Note, however, that while 21 students completed one module, only four of these individuals completed six modules over the course of the experiment.

Another way to determine whether or not students felt more comfortable with spreadsheets was to ask how they would complete a series of repetitive calculations. Students were presented with this scenario: *One morning you count the number of birds on the Eckerd College seawall. You record 54 birds from 8 different species. How do you calculate the percentage of each species?* Before completing an SSAC module, none of the 12 students in the in-class experiment would have used a spreadsheet to complete the task whereas after completing three modules half would use a spreadsheet.

Table 5
Percent Correct on Student Responses for Excel Questions after Each Module

	Pre 1	Post 1	Post 2	Post 3	Post 4	Post 5	Post 6
Q1: Which formula would you type into Excel to add 4 and 5?							
Individual	62	90	87	87	91	100	100
In-Class	42	100	92	100			
Q2: How would you enter 0.0008 into an Excel formula in scientific notation?							
Individual	38	67	87	90	100	100	75
In-Class	83	100	92	100			
Q3: What is the symbol to indicate an absolute cell reference?							
Individual	10	29	40	36	71	50	75
In-Class	0	17	25	67			
Q4: What is an absolute cell reference?							
Individual	14	24	33	36	71	75	75
In-Class	0	17	17	50			
Q5: How would you add a trend line to a graph in Excel?							
Individual	48	62	87	91	100	75	100
In-Class	58	58	83	83			
Number of Student Responses							
Individual	21	21	15	11	7	4	4
In-Class	12	12	11	12			

The positive gains in confidence were also confirmed by actual improvements in Excel skills. For example, before completing a module, 42% of the students in the class experiment could correctly identify the format for addition in Excel whereas all could recognize it afterwards (Table 5, Q1). Similarly, 38% of the individual summer students could recognize how to input scientific notation into Excel before completing a module whereas 67% answered the same question correctly after completing one Excel module (Table 5, Q2). None of the 12 in-class students knew what an absolute cell reference was before completing one module while half correctly answered the question after completing three modules, and 67% could correctly identify the appropriate Excel symbol (Table 5, Q3-4). Many students also felt more comfortable in their abilities to create graphs and add trend lines using Excel. After completing three modules, more of the in-class students felt at ease with graphing in Excel, as reflected by an increased score from 3.58 to 4.25 when responding to the statement, "I can use a spreadsheet comfortably to create graphs" (Table 4, Q1). This parallels an increase in skill level, with 83% of these students correctly answering the question, "How would you add a trend line to a graph in Excel?" (Table 5, Q5).

In contrast, students had varied opinions about whether or not the modules improved their math skills. The in-class students were neutral on this question, with average scores varying from 3.00 to 3.27 (Table 4, Q4). This lack of confidence was reflected in some, but not all, of the tests regarding quantitative content. For example, all 12 of the in-class students improved their scores on the quantitative skills quiz after completing McIlrath's *Vacation!* module whereas half improved after Vacher's *Earthquake Frequency* module (Fig. 1).

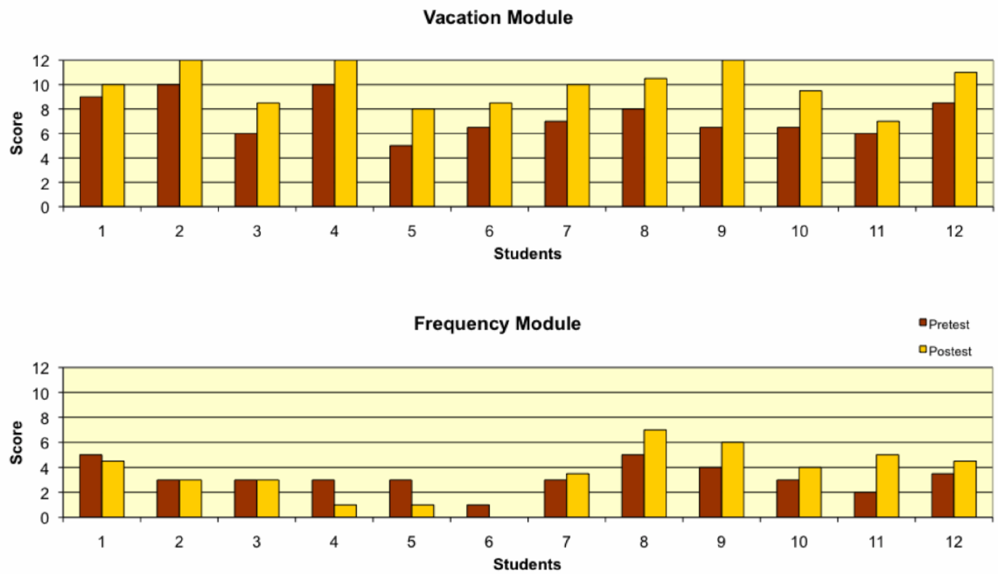

Figure 1. Pre/post-test results for an in-class experiment for McIlrath's *Vacation!* module and Vacher's *Earthquake Frequency* module. The beginner-level *Vacation!* Module, in which all students improved their scores on the in-class quiz, emphasizes basic math skills. The more advanced *Frequency* module, in which half the class had improved scores, stresses statistical descriptors. The maximum score was 12 points for each quiz. (These quizzes are listed as "Additional QL Questions" in the Supplemental File.)

Students who completed modules individually also improved their quantitative skills after completing select SSAC modules. For example, more students recognized the formulae for the surface areas of spheres and circles after completing Butler's module (Table 6, Q1-2). All students recognized the formulae for the volume of a pyramid and the cross-sectional area of a wall after completing Vacher's Giza module (Table 6, Q2-3). After completing Coolidge's module, most students understood the prefix mega-, and more recognized how many grams are in a pound as well as the formula for converting between Fahrenheit and Celsius degrees (Table 6, Q5-7).

Most individual and in-class students also agreed that the modules improved their understanding of concepts beyond the Excel and quantitative content. This is reflected by positive responses to the question, "This module improved my understanding of" module specific context (Table 4, Q5). For example, all students better understood pivot tables after completing Allen's module and knew that CPI is an abbreviation for Consumer Price Index after completing Kiliç-Bahi's module (Table 6, Q8-9). And, after completing Wetzel's module, students

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in both the individual and in-class studies better understood quantitative features of the earthquake magnitude scale (Table 7, Q1-2).

Table 6
Number of Student Responses for Content-Specific Questions after Completing the Specified Modules in the Individual Experiment

	Pretest	Post Test	Correct Answer and Module
Q1: What is this expression used for? $4\pi r^2$			
N	4	4	*A: Surface area of a sphere*
Correct	2	4	Module: Butler, *Climate Change*
Q2: What is the formula for the area of a circle?			
N	4	4	*A:* $A = \pi r^2$
Correct	3	4	Module: Butler, *Climate Change*
Q3: What is the equation for the volume of a pyramid?			
N	5	5	*A:* $V = (1/3) A_b h$
Correct	2	5	Module: Vacher, *Pyramids of Giza*
Q4: Given the volume, how do you find the cross-sectional area of a wall?			
N	5	5	*A: Divide wall volume by length*
Correct	2	5	Module: Vacher, *Pyramids of Giza*
Q5: How many meters are in a megameter?			
N	8	8	*A: 1,000,000*
Correct	2	7	Module: Coolidge, *Is it Hot in Here?*
Q6: How many grams are in one pound?			
N	8	8	*A: 454*
Correct	2	6	Module: Coolidge, *Is it Hot in Here?*
Q7: What is the equation to convert Celsius to Fahrenheit?			
N	8	8	*A:* °F = (9/5) °C + 32
Correct	4	7	Module: Coolidge, *Is it Hot in Here?*
Q8: What does CPI stand for?			
N	6	7	*A: Consumer Price Index*
Correct	1	7	Module: Kiliç-Bahi, *Index Numbers*
Q9: What is a pivot table?			
N	8	8	*A: Interactive summary of large*
Correct	0	0	*datasets (short answer question)*
Partially Correct	0	8	Module: Allen, *Software Piracy*

Table 7
Number of Correct Responses for Content-Specific Questions after Completing Wetzel's *Earthquake Magnitude* Module

	Individual Study		In-Class Study	
	Pretest	**Post Test**	**Pretest**	**Post Test**
Students	3	4	12	12
Q1: The Richter Scale is… Answer: Logarithmic				
Correct	2	4	9	11
Q2: An increase from magnitude 6 to 7 on the Richter Scale corresponds to… Answer: A 10-fold increase in seismogram amplitude				
Correct	2	4	5	7

Overall, most students found the SSAC modules interesting and would recommend their use in college level classes (Table 4, Q6-7). Most also indicated that they were about the right length and difficulty level. In both the individual and in-class studies, students found that the modules became harder as they completed more modules, as shown by the decreasing average score from the first

Table 8
Average Responses to Evaluative Questions after Successive Modules in the Individual Experiment
(5 = extremely easy or too short; 1 = extremely difficult or too long.)

	Post 1	Post 2	Post 3	Post 4	Post 5	Post 6
Q1: How difficult did you find this module? (extremely easy/easy/about right/hard/extremely difficult)						
Individual	3.11	2.87	2.70	2.71	2.50	1.75
In-Class	3.17	2.82	2.58			
Number of Student Responses						
Individual	19	15	10	7	4	4
In-Class	12	11	12			
Q2: The module length was ... (too short/short/just right/long/too long)						
Individual	2.40	2.60	2.91	3.00	3.00	2.00
In-Class	2.67	2.82	2.33			
Number of Student Responses						
Individual	20	15	11	6	4	4
In Class	12	11	12			

to last module completed (Table 8, Q1). This reflects our experimental design in that students started with a “beginner” module and then moved on to “intermediate” and “advanced” modules when students were ready. In the individual study, after the first module, half of the students (10 of 20) indicated that the modules were “long,” resulting in an average score of 2.40 (Table 8, Q2). However, this score increased to 3.0, “just right,” for modules four and five. Module 6 was an “advanced” module for all four individual participants resulting in average scores for module length and difficulty of 2.0 (“long”) and 1.75 (“hard”), respectively. After each module, students in the individual study answered the open-ended question, *How long did it take you to complete the module?* Answers from 59 surveys ranged from 38 minutes to 3 hours, with an average of 1 hour and 40 minutes.

Case Studies

In addition to considering overall student results, we also evaluated a few individual students on a case-by-case basis. The total number of modules completed by each student in the individual study was dictated primarily by one of two factors: time or interest. In many cases, students simply did not have time to complete more modules. In other cases, students found the modules too difficult and therefore not worth the modest stipend in exchange for their efforts.

In one particularly interesting case, a senior psychology major familiar with SPSS, a statistical package, finished Franchy’s module but then gave up during Kiliç-Bahi’s module. In her exit interview, she indicated that Excel formed a barrier to improving her quantitative skills, saying, “I still feel that Excel is a mysterious entity that is intimidating." She also wrote a lengthy response, remarking that the SSAC modules were particularly difficult for her: "I needed to hear explanations before I could understand a problem or concept." She suggested improving the modules by adding more written directions and working through the SSAC modules as a class.

In contrast, many students had positive experiences with the SSAC modules. A senior biochemistry student who completed two modules remarked that the experience improved her attitude towards Excel, saying, "I am applying to med school. I created a spreadsheet to keep track of info and I think I would have done it by hand (before completing the modules)." All four students who completed six modules felt that the experience made them more comfortable with Excel, improving both their Excel and math skills. These gains were confirmed when they were asked specific Excel and quantitative concept questions in the pre- and post-tests.

For example, of the four students who completed six modules, one was a senior literature and theater double major who had never used Excel prior to testing SSAC modules (Student A). After using the modules, she felt she had gained many Excel skills, saying, "Now I'm intermediate and before I didn't even know what it was." In terms of quantitative skills, she improved "a little bit, perhaps more the application of math skills." While she found her first module exceedingly hard, at first she continued because she needed the money, but "then continued because it was fun." Her responses to questions regarding comfort with spreadsheets and improvements in Excel and math skills steadily increased from "disagree" or "neutral" to "strongly agree" from her first to third modules (Fig. 2). Her positive attitude plummeted, however, after completing the fifth and sixth modules, which may indicate that she was not ready to attempt more advanced modules.

Another student who completed six modules was a senior psychology student who knew nothing about Excel before she started (Student B). She was "scared to begin and thought it was just something computer science students would use." In doing the modules, she recalled reviewing a number of concepts she had not encountered recently in college such as logarithms and unit conversions, including conversions from Fahrenheit to Celsius degrees. She also mentioned that the "cost-benefit analysis really got me thinking, especially with respect to environmental ethics." Overall, she felt that the modules improved her comfort with using spreadsheets and her Excel and math skills (Fig. 2) and those impressions were supported by actual increases in Excel (Table 9) and quantitative skills (Fig. 3). For example, she picked out the appropriate symbol for an absolute cell reference after completing her first module (Table 9, Q1) and could explain this concept after finishing her fourth module (Table 9, Q2).

A senior in biology (Student C) who completed six modules said he "always loved Excel and is an avid fan." He maintained, "Excel should be learned in high school. Excel is a great tool that should be used by everyone." His enthusiasm was reflected in his six "strongly agree" responses to the qualitative questions about his comfort with spreadsheets and improvement in Excel skills (Fig. 2). Despite his previous experiences with Excel, he learned new skills by completing

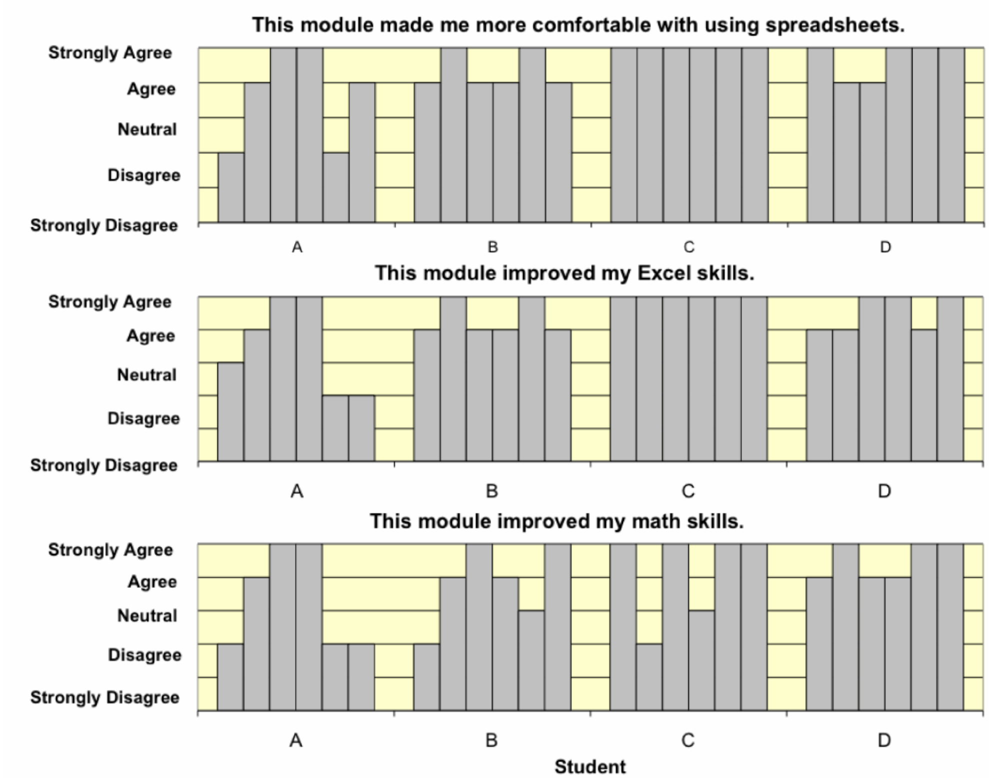

Figure 2. Responses on evaluative questions for the four students who completed six modules over the course of the individual experiments. The students, designated as A through D on the x-axis, felt the modules made them more comfortable with spreadsheets and improved their Excel and math skills. Each gray bar represents a student's post-test response, progressing from responses after the first module on the left to the last module on the right for each student. For example, after her first module Student A disagreed with the statement "This module improved my math skills." Her responses changed to "agree" and "strongly agree" after her second, third, and fourth modules, dipping back to "disagree" after completing her fifth and sixth modules.

the SSAC modules, including pivot tables, new formula formats, and absolute cell references (Table 9). In terms of quantitative skills, he said, "maybe not newly learning but refreshing standard deviations." In two cases, after the Sunderman and Butler modules, he answered more quantitative questions incorrectly *after* he completed the corresponding modules (Fig. 3). He felt the modules were "all very informative and very well laid out."

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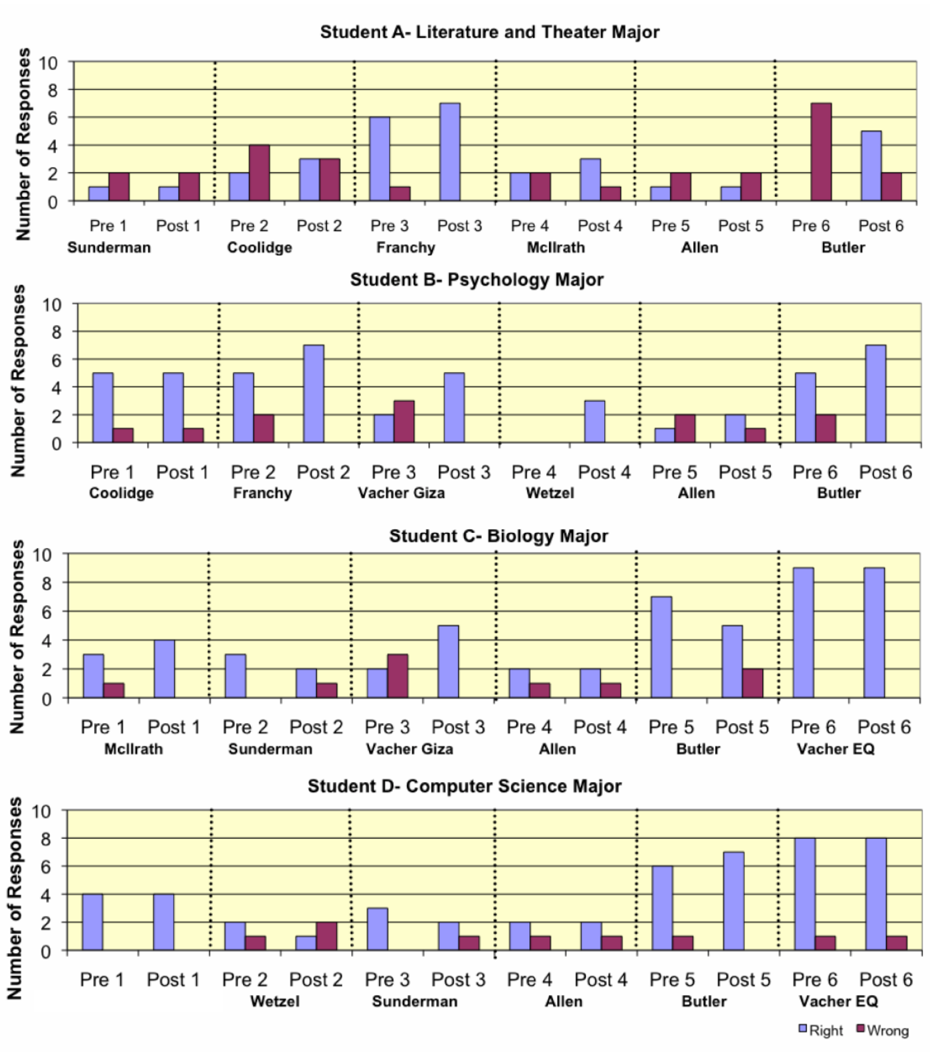

Figure 3. Pre/post-test results on the quantitative-skill questions on each module for the four students who completed six modules in the individual experiment. Student C, for example, completed McIlrath's module first and answered three out of four questions correctly in the pretest and all four correctly in the post-test.

Another senior student who completed six modules was majoring in computer science (Student D). Sunderman's module was his favorite because the "silly premise makes it more interesting." He felt that the SSAC modules were reviewing quantitative skills that he already knew, and this is reflected in his very good pretest scores (Fig. 3). However, he remarked that the SSAC modules were good teaching tools and that he learned a lot of Excel skills, including pivot tables, graphing, and absolute references (Table 9). He was interning at a Pinellas County government office for the summer and said his extensive Excel skills "impressed my boss at work."

Table 9
When the Four Students who Completed Six Modules in the Individual Experiment First Answered Particular Excel-Content Questions Correctly

	Student A	Student B	Student C	Student D
Q1: Which formula would you type into Excel to add 4 and 5?				
First correct answer	Module 1	Pretest	Pretest	Pretest
Q2: How would you enter 0.0008 into an Excel formula in scientific notation?				
First correct answer	Module 2	Module 1	Pretest	Module 1
Q3: What is the symbol to indicate an absolute cell reference?				
First correct answer	Never Correct	Module 1	Module 6	Module 2
Q4: What is an absolute cell reference?				
First correct answer	Never Correct	Module 4	Module 2	Module 2

Discussion

Considering the responses of individuals who participated in the study outside the context of a course, it appears that SSAC modules can improve student learning outside the classroom. Overall, students gained Excel skills (e.g., Tables 5 and 9), improved their quantitative skills (e.g., Fig. 3), and learned content knowledge from individual modules (e.g., Tables 6 and 7). Moreover, many students were learning quantitative concepts without focusing on math skills. When recruiting individual students, we simply asked for their feedback to improve some educational materials. We did not tell students that the primary goal of SSAC modules is to improve quantitative literacy. Because each SSAC module employs Excel, many students were under the impression that the primary goal was to improve their Excel skills. For example, a student who completed one module responded that her math skills did not improve because "all calculations were done by Excel," failing to recognize that she did math in setting up the formulae for Excel.

Furthermore, the responses of in-class students who used the modules in the context of a geology course confirm that SSAC modules help improve students' quantitative skills outside of a formal mathematics course. All in-class students showed improvements in basic math skills, some improved their understanding of statistics, and most students improved their comprehension of logarithms in the context of the earthquake magnitude scale (Fig. 1 and Table 7).

Suggestions for SSAC Module Use

Based on our experiences, I would like to offer some advice to professors planning to use SSAC modules in their own classes. First, it is crucial to match students to the appropriate Excel and quantitative skill levels in the modules. The first module experience is generally daunting for students because they are unfamiliar with the SSAC module format and may be afraid of using quantitative skills or Excel. To avoid undue frustration or resistance during a student's first module, it is better to err on the side of choosing one that is too easy rather than too hard.

Second, use more than one module over the course of a semester, starting with a basic module and progressing through more advanced modules. This strategy allows students to become accustomed to the module format and Excel before exploring advanced topics.

Third, prepare students for what to expect while doing the modules. The modules typically do not take students through problem solving or through Excel step by step, so students must be ready to think and not simply expect to follow detailed instructions. Tell students to open Excel when they start the activity and specify that all spreadsheets shown in the module must be recreated using a combination of data and formula entry. Indicate that the modules are designed to take several hours or more to complete so that students expect an extended activity. Acknowledge that graphing in Excel can be particularly frustrating for beginners.

Fourth, I recommend using SSAC modules in supervised settings rather than as homework assignments. When students can ask questions about Excel or how to solve quantitative problems, they become less frustrated and are more likely to complete the modules. Alternatively, students might begin a module in class and then finish it at home.

Finally, I recommend using the short pre/post tests for quantitative skills that are now available with the instructor's versions of each SSAC module in the General Collection. These take little time for students to complete and allow instructors to easily assess module effectiveness.

Suggestions for SSAC Module Assessment

While our individual and in-class studies provided some useful information about the effectiveness of SSAC modules, I would recommend several modifications for future investigations. First, I would experiment with posing the pre- and post-test questions directly on the computer, perhaps via the Internet. We conducted our tests on paper, which guaranteed that students would not use Excel, a calculator, or the Internet while answering questions, but required us to consume a lot of paper. Furthermore, student responses had to be compiled by hand, requiring an extensive amount of data entry. I would, however, continue to hold personal interviews with students before they start their first module and after they complete their last module. These discussions provided valuable insights into student attitudes towards the SSAC modules and the overall survey format.

Second, I would modify our module pre- and post-tests. Due to the short time frame between receiving supplementary funds from NSF and conducting our experimental assessments, I was unable to ask faculty from other institutions to independently review the survey questions. In retrospect, two of the questions were ambiguously worded and were therefore omitted from the student results and Supplemental File of this manuscript. I also found that some questions could have been clearer and have therefore offered some alternatives in the Supplemental File (cf., italicized text at the end of the Supplemental File).

Many students indicated that the pre- and post-tests were excessively repetitive due to the 23 “core” questions that remained the same for each survey. In the future, I would change the order of the questions and answers to improve variety and combine pre- and post-tests as in the in-class study. For example, students who completed three modules during the individual study completed three pre- and three post-tests whereas those in the in-class study completed a pre-test, two combined pre/post tests, and one post-test.

I would also include more questions assessing quantitative issues. The title slide for each SSAC module specifies “core” and “supporting” quantitative issues. For our studies we wrote targeted questions for all quantitative issues listed on the 10 SSAC modules we assessed. In the future, I would develop several questions for each issue, progressing from testing basic understanding to showing more complex knowledge of the material. I would also develop more complex Excel questions to better assess student’s abilities to apply spreadsheets to solve quantitative problems. However, I would have a maximum of 50 questions for each module, fewer than 10 being open-ended, to avoid student apathy towards the end of the survey. Since the conclusion of our individual study, short pre/post tests for quantitative skills have been added to the instructor’s versions of each SSAC module in the General Collection. I added these questions for the in-class study and would use them again in the future.

Conclusions

The individual and in-class surveys of Eckerd College undergraduates illustrate that SSAC modules effectively employ PowerPoint slides to teach quantitative concepts, Excel skills, and course content. Although many students primarily viewed SSAC modules as vehicles to learn Excel, most learned quantitative concepts, improving their skills outside the context of a formal mathematics

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course. For those wishing to use SSAC modules, for best results I recommend that instructors carefully match student ability with module difficulty, use more than one module over the course of a semester, ensure that students have realistic expectations before starting a module, and facilitate student use in a supervised setting. Finally, assessment methods for SSAC modules, including survey formats and instruments, need improvement by future researchers.

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