Benefits Associated with the Spreadsheet Lab Manual

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“Creating mathematical models using spreadsheets can help students learn at deep levels in both science and mathematics, and give teachers an excellent opportunity to integrate these two disciplines.“ (Horton, Leonard 2005.)

Introduction:

Motivated by my recognition of the need to produce students proficient with spreadsheets and the latest state standards revision, namely STEM, (Integrating Science, Technology, Engineering and Mathematics) I have developed a package of laboratory activities designed for high school science classes entitled The Spreadsheet Lab Manual. This paper describes the growing need for students to become technologically proficient and introduces the Spreadsheet Lab Manual. I will explain and support with current research each of the following in detail.

- How computer modeling and simulations are a necessary element to thorough understanding of advanced topics.
- How manual will fit into the curriculum requirements (STEM) already in place in high schools.
- How step by step instructions in each lab can replace teacher training with teachers learning spreadsheets side by side with their students.
- How general programs like spreadsheets are ideal for high school students laying the foundations of computer literacy.

All of these points can be addressed with the use of the activities in the Spreadsheet Lab Manual. My goal is to extend the use of this package to all science classrooms in order to produce more computer literate students with a deeper understanding of the approaches to solving real world problems.

A Need for Technology on all Levels:

Businesses and industry have quickly realized that spreadsheets are an extremely valuable tool that can dramatically increase efficiency and worker output. In the face of competition and the need to produce people that must enter the work force (Kieffer 1996), colleges have also integrated computers into all aspects of science, engineering, business and economics. However, despite recent emphasis on technology including spreadsheet use, some high school science classrooms are not teaching these skills to adequately prepare their students for college. It has been suggested by many educators that spreadsheets in the classroom are an integral skill that will become an important aspect of education in the new millennium (Ozgun-Koca 2000). “[There has been research and evidence to suggest] the possibility of enhancing students’ capability to shift between a wider range of representations using the modeling approach embedded in computer environments such as a spreadsheet” (Molyneux, Hodgeson, Rojano, Sutherland & Ursini, 1999)
“Not only is a spreadsheet easy to use, but it can also provoke student-centered, discovery-centered learning (Beare, 1993; Beare & Hewitson, 1996; Baker & Sugden, 2003). In the course of utilizing [the] spreadsheet, the interaction between fellow students, teacher and student, and computer and student becomes active (Hershkowitz, Dreyfus, Ben-Zvi, Friedlander, Hadas, Resnick & Tabach, 2002), and as students are enabled to design and manipulate more dynamic and visual spreadsheet models they are also able to explore diverse aspects of a phenomenon (Molyneux, Hodgeson, Rojano, Sutherland & Ursini, 1999; Neuwirth & Arganbright 2004)” (Hong-chan Son & Hee-chan Lew 2006).

With the latest policies that government and medical records are to be stored electronically, students with the highest level of computer literacy will be at an advantage in pursuing these jobs. Spreadsheets are an ideal starting point for students because of their versatility and availability. More specific and more complex mathematical programs such as MathCAD, Polymath or Maple can cause more learning hurdles because of the students’ lack of experience with them, and should be reserved for advanced and college level courses (Lim 2006).

A Proposed Solution:

The Spreadsheet Lab Manual is a package that contains high school level science laboratory activities that can be completed with the use of a computer spreadsheet program. The manual consists of 20 activities designed to enrich the curriculum in Physics, Chemistry, Mathematics, Biology and Environmental Science. With the Spreadsheet Lab Manual teachers can incorporate the use of spreadsheets in their high school classrooms while augmenting the material presently in the curriculum.

The Spreadsheet Lab Manual was produced in order to comply with the New Jersey Core Curriculum Content Standards (NJCCCS) that state that spreadsheets and technology must be incorporated into the curriculum of science classes. There are several primary objectives of the lab manual; the first is to enrich the curriculum in Biology, Chemistry, Environmental Science, Mathematics and Physics. The second is to allow students to solve real problems with substantially more sophisticated models than they typically encounter with traditional problem solving. The third objective is for the students to gain experience and confidence in using a spreadsheet to solve a complex problem. Lastly, the students will see the value and power of spreadsheets as a data analysis tool.

I have implemented the latest versions of the Physics Labs in my classroom over the current school year and the students’ gains have been remarkable. After having completed just a few of the physics labs from the Spreadsheet Lab Manual, my students confidently approach data analysis on a large sample of data using a spreadsheet knowing that formulas have to be entered only once, corrections can be made instantaneously on hundreds of values, and there is no need for repetition on the part of the student who can elicit a computer program to do a repetitive task.

Classroom Requirements

Each lab activity requires only that the student have access to a computer that can run Microsoft Excel 2003 or 2007. All labs are started from a blank spreadsheet and generated completely by the student following the procedures on the handouts. This carries with it several benefits. Students will
appreciate the calculating power of spreadsheets. They will quickly recognize that several hundred to
tens of thousands of calculations can be carried out instantaneously on a spreadsheet, and that being
able to generalize expressions and write formulas for them on a spreadsheet can help model complex
situations.

Also, manipulating input values will allow the students to recognize overall trends in the behavior of
their model and get a more in depth view of the problem at hand. Students often overlook general
trends because they get caught up in the subtle details that go into solving a problem. By first solving
the problem by making a spreadsheet model, the students can then focus their attention entirely on
interpreting the results of their model and develop a deeper level of understanding of the material.
Immediate feedback allows students to view the big picture when manipulating a spreadsheet, rather
than getting lost in tedious calculations. (Rochowicz 2002)

Calculating power put to work.

As a physics teacher, one of my frustrations has always been to tell students to disregard things that are
too complicated for them to deal with. The fact of the matter is some things cannot be done without
math that is well beyond that of even the highest level honors student. I have found as an engineer that
computers are the primary tool for design and that rarely does an engineer develop explicit solutions for
complex problems. They use computer programs that use numerical methods to solve problems. These
numerical methods solve complicated functions that change continually by breaking them up into small
pieces and solving them piece by piece. This is the approach used for generating models in the
Spreadsheet Lab Manual.

The following problem types are solved in the Spreadsheet Lab Manual:

- Terminal velocity (Physics: motion and forces)
- Projectile motion with air resistance (Physics: motion and forces)
- Graphing velocity and position verses time of a rocket with changing mass and air resistance
  (Physics: motion and forces)
- Shifting gears in a car and accelerating it through its power curve (Physics: motion and forces)
- Inflating a balloon and plotting buoyant force and weight vs. diameter (Physics: buoyancy)
- Superimposing Wave functions to observe interference and beats (Physics: waves)
- Performing Electrostatic field, force, potential and PE calculations (Physics: electrostatics)
- Analyzing mathematical relationships in circuits (Physics: current electricity)
- Generating heating/cooling curves for objects (Physics: heat)
- Predicting limiting reactants and percent excess for chemical reactions (Chemistry: stoichiometry)
- Simulating titrations (Chemistry: acid-base reactions)
- Comparing population growth in ideal and logistic models (Biology/Environmental: populations)
- Modeling predator prey interactions in an ecosystem (Biology/Environmental: populations)
- Solving and graphing quadratic and nonlinear equations (Math)
- Investigating functions and their graphs over varying intervals (Math)
- Minimizing cost while manufacturing cans for food storage (Math)
- Modeling investments, compounding interest and amortizations (Math)
- Simulating casino games to analyze the probability of winning or losing (Math)

Model output can be visual giving students an opportunity to analyze graphs and large tables of data.

The NJCCCS have specified that interpretation of trends in data and interpreting graphs are important elements of scientific study. Students will generate graphs in order to solve problems, interpret and describe the trends and behavior of a model, and compare multiple graphs’ behavior, locating intersection points and superimpose graphs to produce new ones. Rather than simply viewing graphs that are given to them, students are given instructions to construct graphs using the spreadsheet program and interpret them in the analysis section of the activity. Not only do the students have to develop and interpret graphs, but they also are required to manipulate the input values and analyze changes in the graphs resulting from these manipulations.

Students entering engineering and science degree programs will gain a large bank of experience in formula writing and data analysis using spreadsheets.

Engineering and science demand the use of computers to analyze large samples of data, model complex situations and generate visual outputs of data such as graphs. As a result, students are expected to be proficient in using spreadsheet programs on a higher level than most other majors. One could suggest that this expectation could be fulfilled by taking an introductory course on using spreadsheet programs. However, unless the course deals specifically with analyzing scientific data, the content of the course will typically be less technical. This is because the content in most instructional courses for spreadsheets is simple material that is easily understood by all. If those courses had Physics, Chemistry, Biology or Math as a co-curricular requirement, they would compromise their primary objective, which is to give basic skills in those programs. By accomplishing the stated objectives in each lab of the Spreadsheet Lab Manual, the same objective of an introductory spreadsheet course will be a consequence of a student’s completion of his or her science requirements in high school. Furthermore, once students recognize the value and time saving capability of spreadsheets, they will immediately put them to use in data analysis of hands-on laboratory activities. Students will go on to college having worked on college level material and gained valuable experience using spreadsheets in the process.

Long term benefits to your students and teachers:

Colleges have to make their students computer literate when they do not have sufficient experience in high school. In some cases colleges require computer literacy courses that include introduction to spreadsheets (Kieffer 1996). Students familiar with the basics having worked on spreadsheets will be less likely to encounter difficulties later on when course materials are more difficult and simulations and computer models are a necessary element of their course work. By offering training in this area to your students, they will be more technologically proficient and have a better understanding of the modeling techniques that are used in science and engineering. Your teachers will expand their own use of technology in the classroom and become geared toward further implementing spreadsheets in the
future. The end result will be students and teachers learning spreadsheets side by side through guided activities that have been proven effective.

Sources


Lim, Kieran F. Use of Spreadsheet Simulations in University Chemistry Education. Journal of Computer Chemistry, Japan v5 n3 p139-146. 2006.


