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Part I

In the past few years, spreadsheets have become a popular computational tool and a powerful platform for performing engineering calculations. Simplified program development and debugging, the use of named ranges and labels that enhance readability of formulas and ability to manipulate matrices aided this heightened popularity. The use of macros for looping and other high-level programming needs, and its widespread availability and portability also promoted its acceptability. Yet, a comprehensive literature review on engineering spreadsheet applications appears lacking. This work fills a gap by presenting a scientific literature review of engineering spreadsheet applications. With this work, new entrants into the field would benefit by having insights into researchable areas, thereby speeding up research and effectively utilising research resources.

Spreadsheets were originally intended for business applications like finance, accounting, and so on. However, the ubiquity and simplicity of spreadsheet programs, in addition to their rich library of built-in functions, plotting capabilities, and other provided utilities, have made them attractive tools for education in engineering as well as other disciplines. This paper presents a brief description of the history of spreadsheets development, and a review of various applications that spreadsheets have in electrical engineering education, especially in the areas of control, electromagnetism, communications and signal processing, electronics, circuits and digital systems, neural networks, power systems, and other fields. The use of spreadsheets in mathematics and other sciences is briefly reviewed, and some possible future trends and applications are suggested.

Spreadsheets have gained increasing popularity in engineering applications, used by both students and practicing engineers. In addition to their low cost, they are easy to learn, and provide the user with the flexibility to display different sets of results just upon changing the input data. This paper illustrates the use of an Excel spreadsheet for solid waste management practices. The program, which has been developed as part of the 'Solid Waste Management' course at the Faculty of Engineering and Architecture, American University of Beirut, allows the user to determine the chemical composition of the waste and its corresponding gas generation potential which are directly linked to a module that allows the prediction of the temporal distribution of gas and leachate production from landfills. The data representing the waste composition and chemistry, gas and leachate production are then automatically plotted into a series of curves and bar charts that allow the decision maker and designer to point out important characteristics, trends and relationships among various parameters controlling solid waste management control systems and landfill operations.

The relatively new Wavelet transform and Wavelet-based algorithms have found applications in virtually all engineering and many scientific disciplines. In this paper we point out their applications in enhancing education both from a teaching point of view and in carrying out laboratory-based experiments and projects. We take advantage of Excel's wide availability and familiarity to students in using it as a medium to bring the power of Wavelet analysis to the classroom and the lab. We give an overview of the implementation the Wavelet transform, inverse transform, and denoising algorithms into Excel, which was realized through a Dynamic Link Library (DLL) and Visual Basic for Applications (VBA) code. We present four examples that relate to education and research. We highlight the advantages of wavelets in detecting trends and events, removing noise, and achieving data compression.

Recent developments in embedding numerical optimization procedures with linear and nonlinear solvers within a spreadsheet environment have greatly enhanced the use of these tools for teaching chemical process design and process integration. Student skills with respect to these topics are usually gained by complex and expensive modular simulators, e.g. ASPEN Plus or algebraic tools such as GAMS or AMPL. However, modular simulators have a significant learning curve, and algebraic modeling languages are usually ignored once students commence careers. This paper demonstrates how the Solver feature of the Excel spreadsheet is used for the optimization of several chemical engineering systems, including pollution prevention problems and mass-exchange networks. Three nonlinear problems are examined: the (a) recovery of benzene from a gaseous emission; (b) design of a chemical reactor network; and (c) solution of material balances in the production of vinyl chloride from ethylene. Dephenolization of aqueous wastes is presented as a linear case. The ease with which these and similar process problems can be formulated and solved within the Excel environment constitutes a major step towards teaching practical optimization and design concepts for university students.

The paper introduces a new idea of using spreadsheets for teaching basics of the discipline called requirements engineering. The discipline is familiar to those dealing with design of complex systems. To this purpose, the authors propose utilizing a specific spreadsheet-based logical simulator. For simulating a computer system on the level of its initial specifications the authors developed a dedicated so-called requirements simulator (RS). For building the simulator, students have to separate the system requirements into a number of abstraction levels. The paper presents a real example of designing RS for the control part of the well-known PARWAN microprocessor using a spreadsheet.

S. Ratnajeevan H. Hoole, Shifla Musthafa, H. M. M. Naleer and **S. Krishnakumar** 949–957 Spreadsheets in Electromagnetics Education: Coupled Problems with Graphical Post-processing

This paper revives the use of spreadsheets and demonstrates that with the new graphical capabilities built into spreadsheets, they can present extensive views of the abstract field. The methodology couples the graphing and cell-coloring capabilities of modern spreadsheets to show how graphs of potentials and color maps of scalar and vector fields can be produced. Further, the ability to link one spreadsheet to another, permits the exploitation of coupled field problems. These abilities are combined with some rudimentary Visual Basic programming to produce the required graphical depictions of the field. The problem of making the use of these spreadsheets less difficult remains because of the need to program the spreadsheets. This is somewhat ameliorated by the instructor giving the required program to students. Alternatively the electromagnetics class may be used in an integrated curriculum to reinforce programming concepts from other classes.

Sebastian A. Maurice and **Robert L. Day** 958–965 A Spreadsheet Method for Promoting Learning in a Non-Supervised Testing Environment

We propose a spreadsheet method that promotes learning in a non-supervised testing environment (NSTE). In a survey response from 157 students in an undergraduate university course consisting of 609 students, we present survey results that show our spreadsheet method was effective in helping students learn the course material and helped them prepare for the exams in NSTEs. Our results suggest that the majority of students can learn in NSTEs without being distracted by different forms of cheating.

M. C. Court 966–973 The Impact of Using Excel Macros for Teaching Simulation Input and Output Analysis

Excel macros are used to teach simulation topics for an undergraduate operations research and simulation course, and a graduate simulation course emphasizing input and output analysis. The macros have the ability to perform simulation analysis when simulation packages are not available (i.e. they are independent of a specific simulation language) and do not require a large amount of CPU memory. These features have lent themselves well to supporting laptop and network independent learning environments. Statistical analysis shows that the macros have also improved overall grade point averages and have reduced the amount of instructional time required to teach these topics.

M. Schumack 974–983 Use of a Spreadsheet Package to Demonstrate Fundamentals of Computational Fluid Dynamics and Heat Transfer

This paper describes how the Solver tool in Microsoft Excel can be used to solve nonlinear systems of equations resulting from finite difference discretization of the governing equations for fluid dynamics and heat transfer. Students learning computational fluid dynamics and heat transfer for the first time typically spend an inordinate amount of time struggling with algorithm development and programming issues. The use of the visual presentation and automated solution capabilities of Excel can help bolster the student's understanding of basic discretization issues unencumbered by programming details. Cell formatting can be used to visualize the geometry and how the grid variables interact with one another, a feature that is particularly helpful when dealing with irregular geometries or staggered grids. Results can be easily shown on contour or x-y plots. Although the number of grid points and thus accuracy is limited by the number of equations that the Solver tool can handle, a spreadsheet model is nevertheless valuable for giving students an intuitive feel for discretization before going on to write code. Two applications are described. The first is a two-dimensional conduction problem that is introduced to show how Solver can be used to solve systems of finite difference equations. The second demonstrates the solution of the incompressible Navier-Stokes equations using the staggered grid formulation. The conduction problem is one that is easily incorporated into an undergraduate heat transfer class, while the flow problem is appropriate for a graduate level course.

Duncan Lawson 984–990 The Blackbody Fraction, Infinite Series and Spreadsheets

This paper shows how Planck's blackbody equation and the resulting formula for the blackbody fraction can be used as a 'real world' example to motivate undergraduate engineers in their study of mathematics. A spreadsheet can be used to give students familiarity with some of the properties of Planck's spectral distribution. The problem of calculating the blackbody fraction can be solved relatively easily using a spreadsheet provided some simple mathematical analysis is carried out first. The mathematical techniques which are required include change of variable, infinite binomial series, integration by parts and sums of geometric progressions.

P. J. Jordan 991–998 A Spreadsheet-Based Method for Thermal Radiation Calculations

The use of a spreadsheet program, e.g. Microsoft Excel, has been introduced as a platform for teaching engineering students to solve thermal radiation problems, particularly problems relating to multi-surface enclosures. The approach developed enables the network equations to be solved using Excel's Solver. The problem is formulated in a general way that permits the user to specify the required number of boundary conditions in the form of any valid combination of temperatures and heat flows. This includes boundary conditions where the net radiation to a surface matches external convection loss to a specified ambient temperature. Calculation of shape factors using user-defined functions written in VBA makes the method very flexible and permits use of redundant information to verify the consistency of the shape factors. The spreadsheet-based approach to radiation calculations is a major departure from the methods currently presented in heat transfer textbooks. The method has been found to be computationally robust and the approach has been well received by students.

Omar A. Iglesias, J. Pastor, A. Henseler, R. Bertolini, J. D. Soto and **C. N. Paniagua** 999–1004 Spreadsheet use in Conceptual Design of Chemical Processes

The main purpose of the following work is to present an elemental simulator of chemical processes developed on an Excel® spreadsheet. The simulator consists basically of three main modules: Property Prediction Block: different physicochemical and thermodynamic properties for pure compounds and mixtures can be calculated; Equipment Block: the main dimensions and output streams of typical process equipment are calculated by means of approximate methods; Cost Calculation Block: the investment required by the different equipments is estimated through generic correlations. Several application examples are introduced, as well as the general structure of the program.

Part II

Frank G. Splitt 1005–1011 Engineering Education Reform: Signs of Progress

The well-being of future generations will depend to a large extent on how we educate our future engineers. These engineers will be a new breed—developing and using sustainable technology, benign manufacturing processes and an expanded array of environmental assessment tools that will simultaneously support and maintain healthy economies and a healthy environment. The importance of environment and sustainable development considerations, the need for their widespread inclusion in engineering education, the impediments to change, and the important role being played by ABET, and several other signs of progress are presented—including the Twelve Principles of Green Engineering.

Research has shown that students often have difficulty seeing the 'big picture.' Because they do not organize their knowledge in a way that facilitates understanding, retrieval and application, they are often unable to apply their knowledge to situations differing from those studied in class. Concept maps are pedagogical tools that help students structure their learning in useful ways. This paper presents the use of concept maps for meaningful learning in engineering. Our intent is to provide a rationale and explain the pedagogical approach underlying our use of concept maps. A distinctive aspect of our use of maps is that rather than being a tool for teaching, concept maps are tools that students use to support learning. Two maps developed for Continuum Mechanics I, a sophomore-level engineering course in the Picker Engineering Program at Smith College, illustrate their application. In this course concept maps were used extensively to communicate ideas, help students see the relationships among concepts, solve problems, and support project work. Student assessment data indicate the effectiveness of this approach in the classroom.

Virginia Commonwealth University is developing an NSF-sponsored 'Experiential Engineering Library' that will provide an easily accessible environment for hands-on engineering learning experiences beyond the traditional mechanical engineering curriculum. The library will foster critical thinking by encouraging students to apply fundamental mechanical engineering principles to emerging interdisciplinary research in fields including microelectromechanical systems (MEMS), bioengineering, and nanotechnology. The present article describes the library concept, elaborates on its contents and provides some preliminary findings.

This research considers a methodology for quality evaluation and improvement of long-term engineering specialization programs. The methodology proposed is based on an adaptation of QFD applied to education. The proposal is followed by the study of a real implementation case in the Product Management and Engineering Specialization Program, which is part of the Continued Education Centre of the Polytechnic School of the University of São Paulo (PECE-EPUSP). The questionnaire and matrices developed and the results obtained are also shown.

This paper presents the methodology and the results of a study which assessed the output of local engineering education systems for an economy in transition. The paper considers the case of engineering education in the Palestinian Territories, which are evolving towards becoming an independent entity. The assessment was performed from the viewpoint of private sector customers in order to examine to what degree local engineering education programs were meeting their expectations. The approach investigated the areas of strengths and weaknesses of the local universities' engineering graduates compared to their counterparts in universities abroad. The results indicated that local university graduates possessed overall competence and were strong in many aspects, such as theoretical and analytical abilities and computing skills. However, there were weaknesses in their applied skills and practical training, technical writing and scientific research capabilities, and English language skills. The results were utilized to establish the outcomes that engineers should achieve. One recommendation is modifying the curricula by accommodating specific topics and courses and enhancing the students' abilities and skills that are identified as needing to be upgraded. Another recommendation is increasing the interaction between the private sector and the universities and establishing university–industry partnership programs.

The Accreditation Board for Engineering and Technology (ABET) EC2000 criteria require that programs demonstrate the ability to work successfully on interdisciplinary teams. This can be accomplished, at least for electrical engineering programs, using teams of students where each individual is responsible for a design aspect that calls for different technical expertise. Thus a project that calls for knowledge in Digital Signal Processing (DSP), software engineering, telecommunications, and use of the Internet would qualify as a venue for demonstrating multidisciplinary teamwork, according to those who represent IEEE at ABET accreditation workshops. In this paper, we describe such a design project, where the goal of the project was the improvement of video quality for real-time video transmission over data networks. Since real-time video is considered, the development can be used for video-conferencing, real-time medical diagnosis, real-time control of industrial processes, or any other use of real-time video.

The use of a commercial Enterprise Resource Planning (ERP) system is integrated into an Industrial Engineering (IE) curriculum. The ERP system, a business information system that considers all facets of a business, provides an integrated presentation that is needed to emphasize the connections and balances of fragmented topics. It also creates an active-learning environment that uses the appropriate technology. In addition, the integration simulates real employment and addresses many industrial concerns. Teaching the industry's needs to students and introducing them to a state-of-the-art ERP system can pave the way for their future development.

This experiment explores the area of mass transfer resistances in heterogeneous catalysis using the light-off curves obtained with a catalytic membrane reactor for the evaluation of diffusional limitations. The catalytic reaction carried out over a $Pt/\gamma-Al_2O_3$ ceramic membrane is the combustion of methyl-ethyl ketone diluted in air at ppm level. Two different flow configurations for gas–solid contact are studied: flow-through and parallel flow to the membrane, showing different activation energies for the overall reaction rate. Therefore, by means of both single experiences the students are able to understand the kinetics falsification caused by diffusion.