Creating Spreadsheet Software as a Team to Solve a Complex Laboratory Experiment

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Abstract

This paper describes the author's experience using a student-team approach to creating a multi-layered spreadsheet to analyze a complex lab experiment. Each student was given a portion of the lab to solve by creating a sheet in a workbook. Each student's sheet is then hyperlinked to the other sheets resulting in a workbook. The workbook directs subsequent lab students through the steps to input the lab data required to process the equations used in the spreadsheets to complete the necessary laboratory analysis calculations. The team creating the workbook is the same team that initially performed the lab experiment. The creation of the spreadsheet helps the students understand the steps that are required to solve the calculations in the lab experiment. The lab experiment involves forced air cooling of a heated cylindrical fin. Thirteen analysis steps were required to process the data gathered in the experiment. The resulting spreadsheet helps students that will later perform the experiment process the lab data. The spreadsheet included an explanation of why each step was necessary and what the assumptions are for using each equation in the spreadsheets. The spreadsheet was created during a two hour lab session with all lab students present and working together to foster the ability to work in a team. Each student was required to understand how their portion related to the other students' work. This further enhanced this team building exercise. The spreadsheet development also helped fulfill a requirement to use computer skills as a component of the class. The lab was comprised of sophomore mechanical engineering technology students.

Introduction

The author had developed a lab for a sophomore level class involving heat transfer. The lab analysis was fairly complex and involved thirteen steps and calculations. Students were usually able to perform the analysis by following written instructions but were not adequately grasping the concepts involved. A second exposure to the lab analysis seemed necessary to reinforce the concepts and discuss the solution steps and their relevance.

One of the learning objectives of the class required students to use computer software in class exercises. The author felt that the students could create a software package that would help following lab groups complete the lab analysis. The lab instructor might then be able to focus on

the concepts for each step as opposed to the computational mechanics of the calculations in future classes. The software creation exercise would expose the current students to the calculations and concepts a second time for increased comprehension. The software development exercise would also help meet the computer use learning objective.

The software would include explanations of why the different formulas were used and any assumptions that were made in using the formulas. This would be done to increase comprehension of the current class that was developing the software and the following classes that would be using the software.

The end result would be a piece of computer aided engineering software that the current lab had created and that future labs could utilize. By creating a piece of analysis software, the current lab students might be exposed to some of the processes involved in commercial software creation and some of the limitations of its use.

Project Scope

The author envisioned a workbook that would prompt the user for data such as room temperature, kinematic viscosity, thermal conduction coefficient, and forced convection air speed velocity. The spreadsheet would then guide the user through the data analysis steps. Steps would include selecting fluid properties based on the inputted data, calculating Reynolds and Nusselt numbers, determining fin efficiency based on fin properties, and determining heat loss through the fin. The workbook was to contain look up tables to determine fluid and material properties. All calculations were to occur in the spreadsheet. Brief explanations of the calculations were to be included as well as any formula assumptions. The explanations and assumptions were to be included to increase the amount of learning that would occur during spreadsheet use and spreadsheet creation. The output was to be a comparison of the predicted amount of heat flow using empirical equations versus the measured amount of heat flow.

Creating the Workbook

Students are assumed to have spreadsheet capabilities upon entering into the degree curriculum. Any lack of knowledge is the burden of the student to acquire by taking a class that does not count towards degree credits or by other means. The students typically have little to no programming language or flowcharting experience coming into the class.

Students routinely used spreadsheets in the author's class to create tables and graphs of laboratory results and perform regression analysis. The students had not before created an interactive spreadsheet that would solve a multiple calculation lab experiment in the author's class. This exercise involved the creation of a workbook consisting of numerous worksheets. This was a new experience for the students to enhance their spreadsheet skills. The workbook was created using Microsoft Excel software.

Workbook Navigation

Each worksheet would perform one step of the lab solution. Navigation between the worksheets would be accomplished by the use of hyperlinks imbedded in each worksheet. The software creation exercise consisted of one lab period at which all eight students were simultaneously in attendance. Due to the short time period, all students would be working at the same time to complete the project. Each student was given a portion of the workbook to complete. One student was assigned to be the coordinator of the hyperlink aspect of the project. None of the students had any experience with using hyperlinks in worksheets. The hyperlink coordinator was assigned the task of determining how the hyperlink function worked, its syntax, and helping others insert hyperlinks in their sheets.

A main menu sheet at the beginning of the workbook was created to enhance workbook navigation. The main menu included text to orient the user to the layout and use of the workbook. It contained appropriate labeled cells that contained hyperlinks to each of the worksheets in the order required to complete the lab analysis. A sentence describing the function of each sheet was included to the left of the hyperlink to that sheet. The bottom of the main menu displayed the results of the spreadsheet analysis. The main menu varied somewhat from the template layout due to its unique function.

The rest of the students were given specific lab steps to perform, each involving the creation of a separate worksheet. The steps dealt with the input of gas properties and the use of formulas to calculate results. Refer to the bibliography[1] for a complete description of the lab experiment being analyzed.

To create uniformity throughout the workbook, the hyperlinks and data transfer cells were inserted at consistent cell locations common to all sheets. Transmission of data between sheets was simplified in that the students always knew where the data to be transferred would be located on the sheet. A remaining difficulty was the determination of which sheets contained which data. This was completed by giving each sheet a name that was indicative of what data or formula it concerned.

Worksheet Template

The instructor created a worksheet template that students used for the creation of individual sheets. It served as the backbone of the entire workbook. The template contained a heading that would be used on each sheet to provide a uniform appearance throughout the workbook. The template included a fairly large area that was surrounded by a border in which the students would insert a graphical depiction of the formula used to perform any calculations in that sheet. Functional equations were imbedded in worksheet cells. Students were instructed to list any assumptions that were made in using the formula below the graphical depiction of the formula. The template included an area in which the students were to insert a brief description of the function that their sheet performed. Included in the template was an area for data input and output. Specific cell locations in the template were given borders and used as data hyperlink locations for transferring that data. The solution procedure required the input of data that was obtained from tables and charts in the class text[2]. A cell that required input data was given a

yellow background color. The sheet included instructions for the user to input any data that was indicated by cells with a yellow background fill color. A brief description of required input information was given to the left of any yellow cell. Values that were calculated by the sheet or transferred from other sections of the workbook were indicated by cells with a green background fill color. A brief description of the calculated or transferred value was given to the left of the each green cell. The template contained a cell labeled "main menu" that linked to the main menu sheet and a cell labeled "next step" that linked to the next sheet in the solution sequence.

Common font style, size, and format were desired throughout the work book for uniformity. Consistency in the use of material property symbols and formula symbols and formats were preferred. These were not always obtained due to poor communication, lack of attention to detail, and the short time frame.

Teambuilding

The author/instructor felt the project was a worthwhile team building exercise. It gave the students a chance to work together as a class on an activity based exercise. The exercise provided a project for the students to complete with minimal supervision. At the beginning of the class the author laid out the objectives, assigned students to certain tasks, introduced and provided the template, answered project clarification questions, and let the class go on their own from there. The author designated the student in charge of the hyperlinks and the student in charge of the main menu as project coordinators. This seemed somewhat natural since the main menu and hyperlinks involved all the other students. The coordinators were to expedite the project and resolve issues as necessary. The author remained in the room but insisted that all issues be solved by the students by whatever means they felt appropriate that would allow timely completion of the project goals. The author provided goal clarification and roadblock elimination when necessary. For example, the instructor produced a floppy disk for copying files when the students had none but desired one.

The students quickly became a group working towards a common goal. The hyperlink coordinator seemed to relish the leading role and moved from computer to computer so as to interface with each student. The hyperlink coordinator created a worksheet naming scheme that each student was to use so that the hyperlink syntax would be manageable and reliable. The naming scheme was drawn on the dry erase board in front of the room for all students to reference along with a crude flowchart that diagrammed the flow of information throughout the workbook.

Overcoming Obstacles

The spreadsheet exercise was performed in a computer lab. Each student had their own computer. After the sheets were completed it was necessary to compile the individual sheets into one workbook. The instructor required the students to create their own method to the compilation process. The computers were connected to a common server. The students attempted to save the individual files to a common file on the server but were not successful. They decided to save all the sheets to one floppy disk. A substantial amount of time was consumed during the copying and transferring of the files and disk. The students expressed

dissatisfaction about the loss of time during the copying process. Many suggestions were made by students regarding more efficient ways to handle the file transfers.

Each student was required to test their work by inputting sample data and verifying the return of valid results. One student used units that were not consistent with the rest of the class. This discrepancy was not uncovered during the testing phase. The entire workbook failed as a result. The lab time had expired and there was no time to debug the workbook. This provided a valuable group lesson in the need for communication, consistency, thorough testing, and adequate time allowance for a debug phase.

The exercise provided an opportunity for the class to perform project work in a group setting. The students were exposed to issues that happen in real world projects. The students saw the need to adapt to the circumstances to succeed. The students learned to cooperate with other students to reach a common goal.

The students were exposed to the dynamics that result from group work. One student needed explicit directions to complete the work. One student went off in a different direction from the group. Some worked to provide clarification and commonality within the group. Some browsed the internet when they felt they had completed their obligation. The author should have foreseen the imbalance in workload and abilities among students and provided a means to even the balance. The coordinators rose to a perceived challenge and worked hard to complete the project successfully. They seemed to feel an extra degree of responsibility for its completion. As in many groups, some complained, most cooperated, and a few excelled.

The exercise helped build networks between the students. The class was held at a commuter campus where most students have full time jobs and little time to network with other students. The project put them in a different setting with their fellow students where they must interact to work towards a common goal.

Conclusion

The completion date for the lab was the end of the lab period. All worksheets were created and assembled into a workbook. The workbook was flawed due to one worksheet using units differing from the rest of the workbook. A coordinator volunteered to work past the lab period to debug and enhance the workbook. The rest of the students expressed an interest in the results and some time was spent in a subsequent class discussing the lessons learned in the exercise.

The workbook was left in a rough state of completion. A discussion ensued about how far to take a project and the engineering dilemma of always wanting to go one more step before concluding a project. A student could easily spend an entire semester enhancing the workbook and still have many more ideas for additional improvements.

The lab has not yet been repeated so the workbook has not been utilized by subsequent students. Feedback from the students that created the workbook ranged from very positive to mildly negative. The negative comments typically dealt with having too little or too much work

to do in the amount of time allotted. The comments may have been more uniformly positive if the author would have distributed the workload differently.

The author tried too accomplish too much in the allotted session. The scope of the project was far too large for a two hour lab session. Several more lab sessions are required to complete the workbook. This creates the opportunity for future classes to learn from the experiences of the previous class and to build on what has been accomplished.

Bibliography

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