

Automated Grading of Microsoft Excel Spreadsheets

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Introduction

Microsoft Excel is a tool that all disciplines of engineers use for calculations and data visualization. Because of this, each engineering student at California Baptist University is required to take a course in data and geometric visualization. One element covered in this course is Microsoft Excel, to provide the students skills graphically presenting numeric data. One challenge in grading these classes is the time lag between when students submit their assignment and when they receive feedback on their work. By the time students receive their graded assignment, most only care about their grade, but are not interested in how they can improve. Because of the time and effort in grading, allowing students to resubmit their work is not practical. In an effort to improve students learning and reducing professors time spent in grading, this paper explores the automation of grading of students work in Excel at a private University.

Background

All engineering students at California Baptist University are required to take Visualization Languages, a course in which students learn both AutoCAD to communicate geometric data, and Excel to graphically express numeric information. An automated grading system for the AutoCAD portion of the course was shown to be beneficial to both the students and faculty [1], so the next step was to explore automated grading for Excel.

Since the financial world commonly uses Excel, the first automating grading efforts have been directed towards financial analysis spreadsheets. Hill [1] (2003) developed Microsoft Access application MEAGER which compared students' spreadsheets in a directory to an instructor key, indicating the differences. It was able to grade text, numbers and formulas as well as cell formatting. Feedback is given to students through a strike through format on the cell, as well as a cell comment.

Kline and Janiki (2003) [2] use a visual basic program to automatically grade excel files submitted through a web page. The web page also generates custom spreadsheet starting files for each student. Their program checked formulae and ranges as well as basic graph properties. Although grading was automated, the program still needed to be run by a person, so feedback was not instantaneous.

Blayney and Freeman(2004) [3] provided students spreadsheets with embedded macros to provide students feedback in a timed assignment. They use similar macros to grade the students' assignments. This has the disadvantage that they need to program each assignment needs individually.

Waldman and Ulema (2008) [4] created a customized code designed to grade a specific excel assignment, rather than a generalized tool for an information systems class. They used JEXCEL_API to load the necessary information from the excel file.

Kovačić and Green [5] (2012) rely on a different approach in that students do not send in their spreadsheet, but answer questions based on the spreadsheets that the students prepare. They have

designed online quizzes to test the items that students put in different formulas for a specific assignment.

Matthews et al. [6] (2013) developed an automated grading system for excel and database assignments. For the assignments, a database is kept of correct and incorrect answers for each cell. For incorrect answers, instructor feedback is also recorded. For answers that have not been marked as either incorrect or correct, the grader chooses the level of credit and appropriate feedback providing a learning system. This greatly reduced the time in grading. The program was able to grade both cell items as well as chart items.

McNeil [7](2015) developed a visual basic add in for excel to aid faculty in grading excel worksheets. To check for accuracy of formulae, the formula the value of the formula is compared to the solution as well as the formula is copied into the key worksheet and the results are compared. The instructor has the option of automatically emailing the students' their grade on the assignment.

Cohenour and Hilterbran [8] (2016) created an automated grading program in MATLAB which compares student worksheets with an instructor provided Grades were done on a batch process d students were given feedback by email. Grading was limited to cell formulae.

In summary, several approaches have been undertaken for computer-assisted grading of excel spreadsheets. Many require dedicated programming for each assignment, which limits their flexibility. Some are able to grade graphs as well. None of the published works allows for complete automation without instructor interaction. This paper discusses the development and implementation of a completely automated grading program for excel spreadsheets and graphs.

Program Operation

An automated grading program has been developed in the LabVIEW programming language. The program communicates with Microsoft Excel using ActiveX to read information about each sheet in the file, as well as all of the charts in the file. The program also communicates with Microsoft Outlook through ActiveX, allowing the program to automatically download and grade students' homework submissions. After grading the students' work, the program then sends an email reply to the student with feedback on their submission. Students are then able to read the feedback and make corrections to their assignment until the due date for the assignment.

To set up an assignment for grading in the grading program, the instructor provides a spreadsheet that the grading program uses as the key in grading the assignment, as well as the grading rubric for the assignment. The instructor enters the grading rubric as lines in a spreadsheet. Table 1 shows an example of the spreadsheet format for grading excel sheets for an introductory chapter tutorial. The instructor provides the email subject line, due date, key spreadsheet name, and the sheet number in the key spreadsheet to grade. Then, for each item that the instructor wants grades, they enter a point value. In the example, the sheet tab title and spreadsheet formulae/values is graded on all sheets, the number format is graded 3,5 and 6, the borders are graded on sheets 5 and 6, while the font is only graded on sheet 6. For grading the cell contents, if a cell in the key contains a formula, the program checks to see that the student used a formula in their calculations and that the result of the formula resulted in the same value. This has the downside that an error somewhere else in the spreadsheet result in a cell graded as incorrect.

Table 3, Line Grading Options

Chart #	Chart Type	series name	XY data	1st/2nd axis	dash style	line weight	line color	begin arrow	end arrow	marker style	marker size	marker fill color	data labels
1	1		1		0.25								
1	1	0.5	0.5	0.5						0.5			

Table 4, Chart Trendline Grading Options

Chart #	trendline type	trendline order	trendline disp eqn	trendline disp Rsqr	trendline backward	trendline forward	trendline name	trendline name is	trendline dash style	trendline weight	trendline begin arrow	trendline end arrow
1	1	1	0.25	0.25								
1	1		0.5	0.5								

Table 5, X and Y Axis Label Options

Chart #	X Axis title	X Axis Title Font Name	X Axis Title Font Size	X Axis Title Font Color	X Axis Title Font Bold	X Axis Title Font Italics	X Axis Labels Font	X Axis Labels Font Size	X Axis Labels Font Color	X Axis Labels Font Bold	X Axis Labels Font Italics	Y Axis title	Y Axis Title Font Name	Y Axis Title Font Size	Y Axis Title Font Color	Y Axis Title Font Bold	Y Axis Title Font Italics	Y Axis Labels Font	Y Axis Labels Font Size	Y Axis Labels Font Color	Y Axis Labels Font Bold	Y Axis Labels Font Italics	
1	0.1											0.1											
1	0.5											0.5											

The instructor is able to interact with the program by email, adding new solution files and updating the grading rubric file. In addition, the instructor can email the program a Blackboard Course Management grades list file, and the program will update the grades in the file, if the grades represent an improved grade.

Student operation

Since the grading program compares specific cells to an instructor provided key, the instructor needs to provide the students an image of the spreadsheet indicating the cell locations of the different items. After completing the assignment, students submit their work to the grading program by email, using the subject line to indicate the assignment that they are submitting. When the dedicated grading account receives an email, the grading program automatically grades the students work and replies by email with the graded assignment. For spreadsheet cell items, students are provided a summary email with the items graded and the corresponding

points. Figure 1 shows a sample student email. In this example, the student had some incorrect items in their spreadsheet and the wrong linetype for the second series, and the wrong series name for the second series.

Due Date is 11/9/2017 at 11:59 PM

Total Assignment Score (9.37 / 13.00)

Key Worksheet 8: "HW4 Hookes"
(4.87 / 6.00) Worksheet

Key Chart 1: "Hookes law is accurate" (4.50 / 7.00 total)

- (0.50 / 0.50) Has legend
- (0.50 / 0.50) Legend Position
- (1.00 / 1.00) Chart series 1, Chart Type
- (0.00 / 1.00) Chart series 2, Chart Type: You had <XYScatterLines> and the key had <XYScatterLinesNoMarkers>
- (1.00 / 1.00) Chart series 1, series name
- (0.00 / 1.00) Chart series 2, series name: You had <F (N) from Hookes Law> and the key had <Hooke's Law>
- (0.50 / 0.50) XY data: Key chart series Data
- (0.00 / 0.50) XY data: Key chart series Hooke's Law
- (0.50 / 0.50) Axis 1, X axis title
- (0.50 / 0.50) Axis 1, Y axis title

Figure 1, Sample Student Email

In addition to the email, the program returns the students spreadsheet as an attachment. In the returned spreadsheet, the program adds comments to each cell where student had a mistake, indicating the difference between the students' submission and the key. Figure 2 shows the corresponding spreadsheet that the program returned to the student. From the comments, the student can see that in D1 he had the wrong text, and for column E, The student was supposed to use the trend function, while the student just used the slope and the first point. When the student receives the email, he has the option of fixing any mistakes that he made and resubmitting their spreadsheet until the due date for the assignment.

	A	B	C	D	E	F	G	H	I	J
1	m (g)	x(cm)	x (m)	Data	F (N) from Hookes Law	Formula: you had "Data" and the key had "F (N)"				
2		20	0	0.1962	=K*C2+con	Formula: you had "=K*C2+con" and the key had "=TREND(\$D\$2:\$D\$9,\$C\$2:\$C\$9,C2)"				
3		30	1.3	0.013	0.2943	0.290141716				
4		40	2.7	0.027	0.3924	0.391309718				
5		50	3.9	0.039	0.4905	0.478025149				
6		60	5.4	0.054	0.5886	0.586419437				
7		70	6.7	0.067	0.6867	0.680361153				
8		80	8.1	0.081	0.7848	0.781529155				
9		90	9.5	0.095	0.8829	0.882697157				
10										
11		K	7.226286	N/m						

Figure 2, Student Spreadsheet with Comments

Implementation

The grading program is used in a required first year course in both AutoCAD and Excel, which is a required course for all engineering majors. The first semester the program was used it was piloted in only one of four sections of the course. Students in the other sections were able to submit their work to the program for feedback, but a grader graded the students' work. In general, students preferred the automated grading, so it was adopted across the college of engineering the following semester. The program was initially used with Kuncicky and Larsen's *Introduction to Excel* (5th Edition) [9] and later with Liengme's *A Guide to Microsoft Excel 2013 for Scientists and Engineers*. [10].

Figure 3 shows a boxplot of the range of grades on the excel test in the course before and after the program was implemented. Grades are from two different professors. For professor 1 who wrote the program, the median grade rose from 77 to 86 in classes of 25 students. For professor 2, the median grade lowered slightly from 93 to 90 from Fall 14 (52 students) to Fall 15 (56 students) while the median raised slightly from S15 (18 students). The difference in improvement could be partially due to professor 2 having to learn the grading program. Also, a new textbook (Lengme) was introduced in Fall of 15 which was based on Excel 2013 rather than 2010.

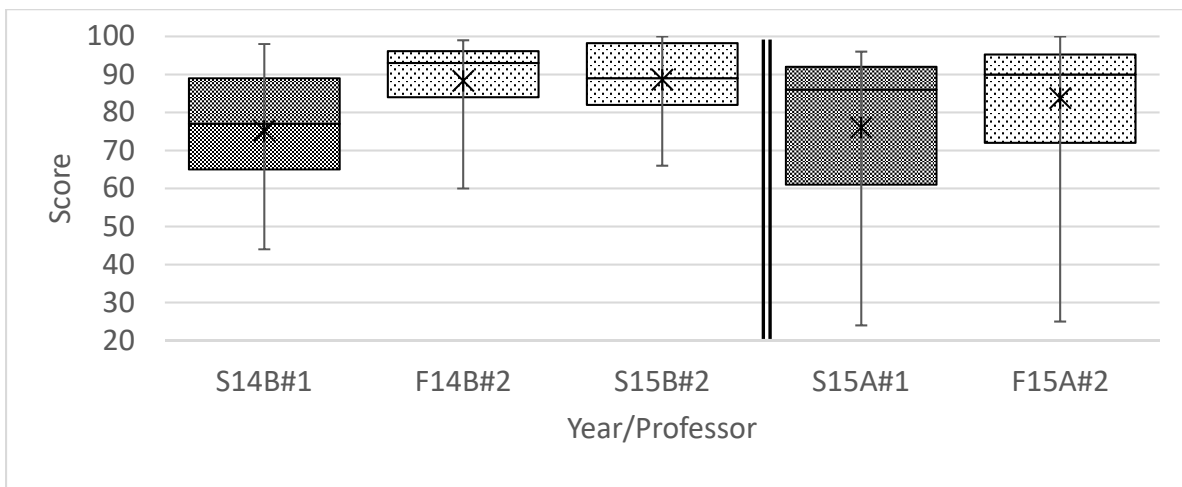


Figure 3, Boxplot of students' test grades, middle quartiles with X as average. B is before automated grading, A is after Automated Grading. Divided by professors 1 and 2.

Initially, students were assigned both on the tutorials in the textbook as well as additional homework problems at the end of the chapter that required skills from the tutorials. The faculty found that some students were spending a significant amount of time trying to get the last fraction of points on the tutorials (e.g. getting the cell border style correct) even though they had grasped the concepts that the tutorials were trying to teach. Because of this, the instructors changed the grading policy so that the tutorials no longer counted towards the students' grades, but students could still submit the tutorials for feedback.

Due dates with penalties for late work were also added to the program to encourage students to keep up with the work. Before due dates, students would put off their homework for this course, and would fall too far behind to recover.

Student survey

At the end of the Spring 2017 and Fall 2017 semesters, students were given a small amount of extra credit to fill out an anonymous survey concerning their experiences with the excel grading program. Students were asked to evaluate the statements between (1) strongly agree and (5) strongly disagree. During the spring semester of 2017, the college offered four sections with two professors, and during the fall semester of 2017, there were five sections given by three different professors. Figure 4 shows the in the survey as well as the number of students who responded in each of the rankings. Table 6 shows the percentage of students with positive (Strongly Agree or Agree) experiences with the grading program. All of the questions invoked a positive response, though the most room for improvement is with the email graphs and report. Overall, only a quarter of the students would prefer traditional grading.

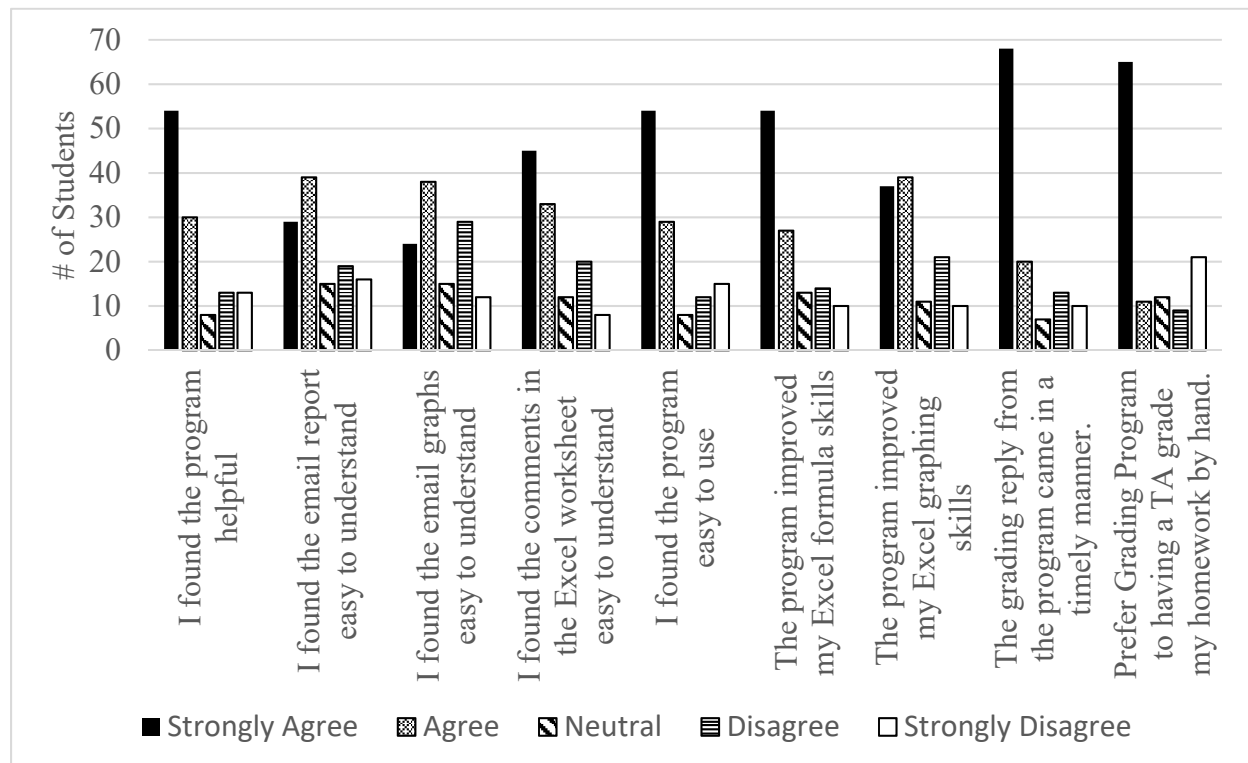


Figure 4, Summary of 118 Student Responses

Table 6, Percent of students with positive and negative answer

	% pos.	% neg.
I found the program helpful	71%	22%
I found the email report easy to understand	58%	30%
I found the email graphs easy to understand	53%	35%
I found the comments in the Excel worksheet easy to understand	66%	24%
I found the program easy to use	70%	23%
The program improved my Excel formula skills	69%	20%
The program improved my Excel graphing skills	64%	26%
The grading reply from the program came in a timely manner.	75%	19%
Prefer grading program to having a TA grade my homework by hand.	64%	25%

Conclusion and future work

An automated grading program for Microsoft Excel files has been implemented in a first year course in an engineering program at a private liberal arts college. The program provides rapid feedback to the students, and greatly reduces the workload on the faculty and teaching assistant for the course. Overall, students have had a positive experience with the program and feel that it has helped them improve their abilities in Excel.

In the future, the program could be implemented across the campus in the Info Systems Essentials course, a general technology education for the college. The program has been discussed with a couple of professors who teach that course and they expressed interest in potentially using the program in their course.

References

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