# Redevelopment of a Freshman Computing Course Based on Student Feedback and Industry Needs

**David Calamas, Aniruddha Mitra, and Brian Vlcek**
*Department of Mechanical Engineering, Georgia Southern University*

## Abstract

The Mechanical Engineering Program at Georgia Southern University recently redeveloped a freshman computing course based on student feedback on senior exit surveys as well as feedback from the department's Professional Advisory Committee. The course was a traditional computing course which covered basic programming principles such as logical, relational, and conditional statements as well as loop structures. These programming concepts were implemented in MATLAB due to its widespread use in academia. However, feedback from the Professional Advisory Committee and alumni in industry indicated that coverage of spreadsheet tools and other software used for documenting engineering calculations might better serve the needs of industry. As such, the course was redeveloped from scratch. In addition to basic programming principles, the course now covers spreadsheet tools (in Microsoft Excel) as well as software for documenting engineering calculations (PTC Mathcad). A recent survey of alumni in industry confirmed the redeveloped course content should better serve future alumni who pursue careers as practicing engineers in industry. The structure and content coverage of the new course will be presented in addition to survey responses regarding software used in industry.

## Keywords

Curriculum, Programming, Spreadsheet Tools, Computing, Freshman

## Background

As with many peer institutions, the Mechanical Engineering program at Georgia Southern University required that undergraduate students, typically freshman, enroll in and complete a programming course. The course, entitled "Computing for Engineers" was informally known as the "MATLAB" course. However, upon analysis of Senior Exit Survey data, and through feedback gained from semi-annual Professional Advisory Committee (PAC) meetings, it was ascertained that the course might not be serving the needs of the program's constituents. Based on this feedback the program determined that the course should be significantly revised. A detailed rationale for this course's redevelopment is outlined below.

## Student Population

The Mechanical Engineering Program at Georgia Southern University has graduated 541 students since the Fall of 2013. The number of degrees awarded by the program in each academic year can be seen in the table below. Over the past five academic years, 95.7% of the undergraduate students who enrolled in the program were residents of the state of Georgia. In order to keep track of the career progression of alumni, the program maintains an alumni group on LinkedIn. Of the 541 recent graduates, 142 (26.2%) are members of the alumni group.

**Table 1 Degrees Awarded per Academic Year**

| 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | Total |
|---|---|---|---|---|---|
| 59 | 105 | 115 | 119 | 143 | 541 |

## Senior Exit Survey

A senior exit survey was administered to the undergraduate students upon completion of the program's degree requirements. The survey is administered at the end of each semester in MENG 4612 Mechanical Engineering Senior Seminar and 456 of the 541 students (84.3%) who have graduated from the program in the past five academic years have completed the survey. Based on the size of the population and of the sample, the margin of error based on a confidence level of 95% in the results of the senior exit survey was found to be approximately 2%. Of particular interest regarding the rationale behind the redevelopment of this freshman programming course were the following two questions:

1. How would you rate your skill level using MATLAB, MAPLE, etc.?
2. How would you rate your skill level using computer programming?

The students surveyed self-identified their perceived skill level based on the following scale:

**Table 2 Senior Exit Survey Scale for Self-Identified Skill Level**

| 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| Excellent | Very Good | Good | Fair | Poor |

It should be noted that the first question in consideration is software application (and programming language) specific while the second question pertains to the students' perceived comfort with the principles utilized in computer programming – regardless of the programming language. The average results from the senior exit survey can be seen in the figure below. The students' self-reported skill level follows a normal distribution. Unfortunately, 28% of the students surveyed rated their skill level using MATLAB at a level of fair or poor. Not surprisingly, 28% of the students surveyed also rated their skill level at computer programming at a level of fair or poor. These results could also be quantified using composite averages. The students' self-reported skill levels using the software MATLAB and applying computer programming principles resulted in near-identical composite averages of 3.1/5.0. If it is assumed that the skills levels correlate directly with letter grades, then a skill level of 5 is equivalent to a letter grade of 'A,' a skill level of 4 is equivalent to a letter grade of 'B' and so on. Therefore, a composite average of 3.1 is akin to a letter grade of 'C.' Alternatively, if the skill levels are assumed to translate to a numeric grade out of 100, then a composite average of 3.1/5.0 is equivalent to a numeric grade of 62/100 (a composite average of 3.5/5.0 would be equivalent to a numeric grade of 70/100). In any case, the aforementioned results from the senior-exit survey

warranted a review by members of the assessment committee and a presentation to the program's Professional Advisory Committee (PAC).

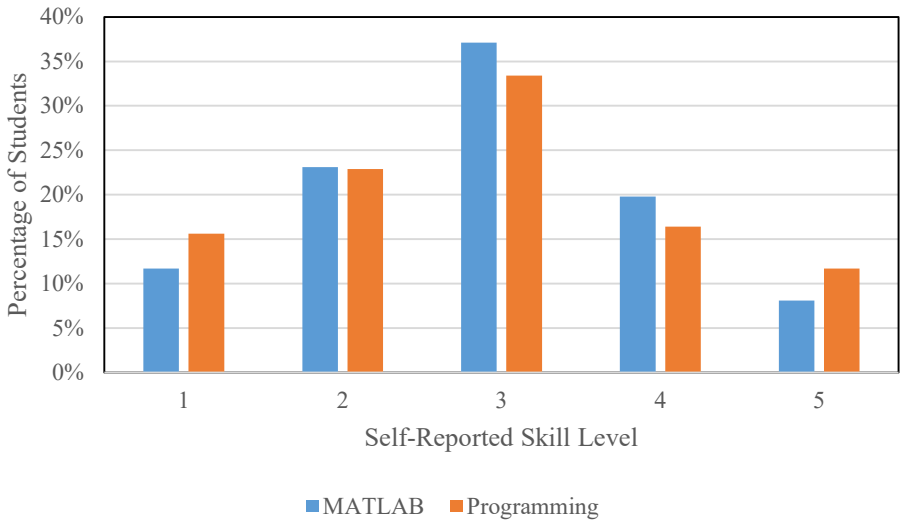


**Figure 1 Senior Exit Survey Data Regarding Computer Programming**

## Professional Advisory Committee

Upon presentation of the aforementioned results from the senior exit survey, it became apparent that the students' self-reported ability to utilize and apply computer programming principles was at an undesirable level. Even so, members of the Professional Advisory Committee (PAC), vocalized that in general, the students that they employed were rarely required to program in any language and at any level. It should be noted that members of the PAC are representatives from industry in the region - the southeastern region of the state of Georgia. It was important for the program to carefully listen to the recommendations of the members of the PAC because nearly 84% of the students who graduated from the program were employed in the state of Georgia.

Furthermore, approximately 90% of the students surveyed were employed in the southeastern region of the United States (more detail in regard to this survey data will be provided below). Therefore, even though many engineering programs throughout the nation offer their own equivalent to the program's "MATLAB" course this did not necessarily indicate that the course met the needs of the constituents of this specific program. In support of this notion, members of the PAC indicated that it would be more beneficial to their companies to focus more on spreadsheet tools rather than computer programming principles.

## Survey of Alumni

After receiving feedback from the PAC and further analyzing the results obtained from the senior exit survey, the program distributed a survey to alumni via a LinkedIn group. Of the 142 members of the LinkedIn alumni group, 52 (36.6%) chose to complete the survey. Thus, 52 of the 541 (9.6%) of the alumni who graduated in the last five academic years were surveyed. This sample size translated to a margin of error, based on a 95% confidence level, of 13% on the

LinkedIn survey. Based on the senior-exit survey and the feedback from members of the PAC, the alumni were asked the following questions:

1. Do you utilize any computer programming in your current position? If so, in which language?

2. Do you utilize any spreadsheet software in your current position? If so, using which software package?

Results from the LinkedIn survey of alumni can be found in the figures below. Upon analyzing the results from the survey of alumni, it became readily apparent that the current structure of the course was not serving the needs of the program's constituents. More specifically, 65.4% of the alumni surveyed did not require the use of computer programming in their current positions (see label 'N/A'). Also, only 11.5% of the alumni surveyed reported using MATLAB in their current position. In fact, even though programming was taught in the MATLAB environment, a larger percentage of alumni utilized Visual Basic (17.31%). However, and in good support of the recommendations of the PAC, 100% of the alumni surveyed utilized spreadsheet tools in their current position. Not surprisingly, 100% of the students utilized Microsoft Excel as the spreadsheet software utilized by their employer. Interestingly, all of the alumni who utilized Visual Basic were doing so to write Macros inside of Microsoft Excel with the intent to automate repetitive tasks within their spreadsheets. It should be noted that the alumni could choose more than one software application which is why the survey indicated that approximately 11.5% also used Google Sheets and 1.9% also used Apache Open Office.

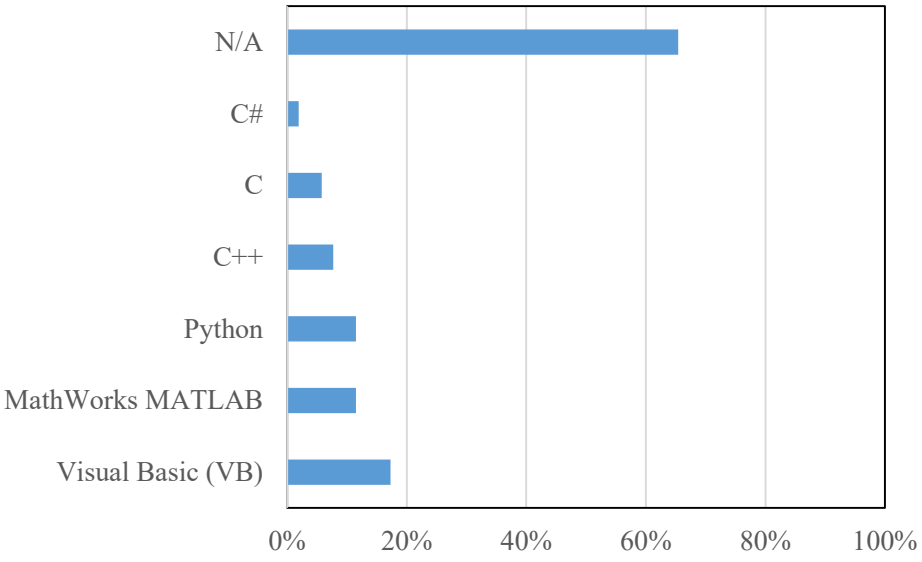


**Figure 2 Alumni Survey of Use of Computer Programming in Current Position**

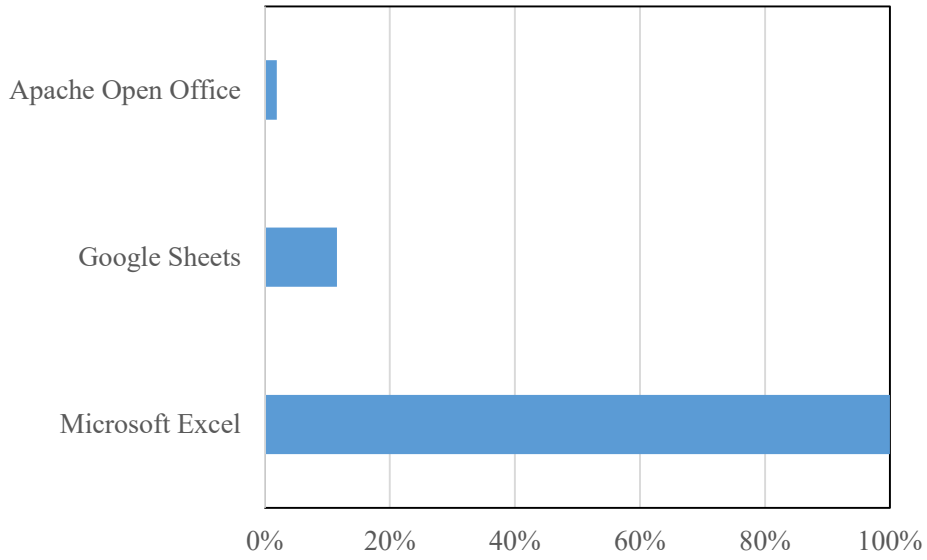


**Figure 3 Alumni Survey of Use of Spreadsheet Tools in Current Position**

## Course Redevelopment

Based on the results from the senior-exit survey, feedback from industry representatives, and feedback from alumni it became clear that the introductory computing course should contain a significant focus on spreadsheet tools. While the previous course focused solely on computer programming principles in the MATLAB environment, the revised version of the course now covers spreadsheet tools in Microsoft Excel, engineering calculations in PTC Mathcad, and computer programming in MATLAB. It should be noted that for brevity the content coverage of the course prior to revision is not outlined. However, in general, the structure of the course and the material presented were aligned with Chapman's *MATLAB Programming for Engineers* text[1].

One of the intended outcomes of the revised course is to expose students to a wide variety of ways to solve a range of problems using different software applications. In this manner, the students should ascertain the advantages and disadvantages of each of the aforementioned applications. As such, rather than introducing each software package independently, the course is organized into discrete topics where each of the software is utilized in tandem. An outline of the revised course content coverage can be found below. In regard to the time allotment of the course content, one should note that the course meets twice per week for a duration of two hours (i.e., two credit hours and four contact hours). The Microsoft Excel content is now sourced from Gottfried's *Spreadsheet Tools for Engineers Using Excel* text[2] while the MATLAB content is obtained from Palm's *MATLAB for Engineering Applications* text[3]. While there are discipline-specific textbooks that utilize Mathcad to solve a variety of engineering problems[4-6], as of the writing of this manuscript one does not exist which utilizes the most recent version of Mathcad (currently PTC Mathcad Prime 5.0). As such, the Mathcad content was developed in-house by the instructors of the course.

It should also be noted that there are no pre-requisites for the course as the program recommends that it be taken during a student's second semester. The co-requisites for the course are

concurrent enrollment in MATH 1112 College Trigonometry, MATH 1113 Pre-Calculus, or MATH 1441 Calculus I. Therefore, it is important to note that the instructor is not expected to teach the background theory behind the various mathematical topics presented or utilized in the course. Instead, the purpose of the course is to introduce various software tools that can be used to solve application-centric engineering problems.

**Table 3 Course Content Coverage and Time Allotment**

| Topic | Week(s) | Percentage |
|---|---|---|
| Introduction to Excel | 1 | 6.67% |
| Introduction to Mathcad | 1 | 6.67% |
| Introduction to MATLAB | 1 | 6.67% |
| Array and Matrix Operations | 1 | 6.67% |
| Functions | 1 | 6.67% |
| Flow Charts and Conditional Statements | 2 | 13.33% |
| Loop Structures | 2 | 13.33% |
| Graphing | 2 | 13.33% |
| Statistical Analysis | 1 | 6.67% |
| Fitting Equations to Data | 1 | 6.67% |
| Sorting, Filtering, and Transferring Data | 1 | 6.67% |
| Unit Conversions | 1 | 6.67% |

## Student Feedback

A survey was distributed to the students currently enrolled in the course at the end of the first semester in which the redeveloped course was offered to ascertain if the content coverage was appropriate and effective. At the time that the survey was distributed, 155 students were enrolled in the course (across six sections); of those, 42 (27.1%) chose to complete the survey. The margin of error, based on a 95% confidence level, for the results of the survey, was 13%. Of significant interest to this manuscript were the following two questions:

1. Prior to taking this course, how would you rate your skill level using the software tools MathWorks MATLAB, Microsoft Excel, and PTC Mathcad?

2. After taking this course, how would you rate your skill level using the software tools MathWorks MATLAB, Microsoft Excel, and PTC Mathcad?

As with the previous surveys, the students self-reported their perceived skill level using a five-point Likert scale (see Table 2). The results from this survey can be seen in the figure below. Prior to taking the course, 2%, 14%, and 3% of students self-reported their skill level using the software applications MATLAB, Excel, and Mathcad respectively as “Very Good” or better. After taking the course, 43%, 74%, and 49% of students self-reported their skill level using the software applications MATLAB, Excel, and Mathcad respectively as “Very Good” or better.

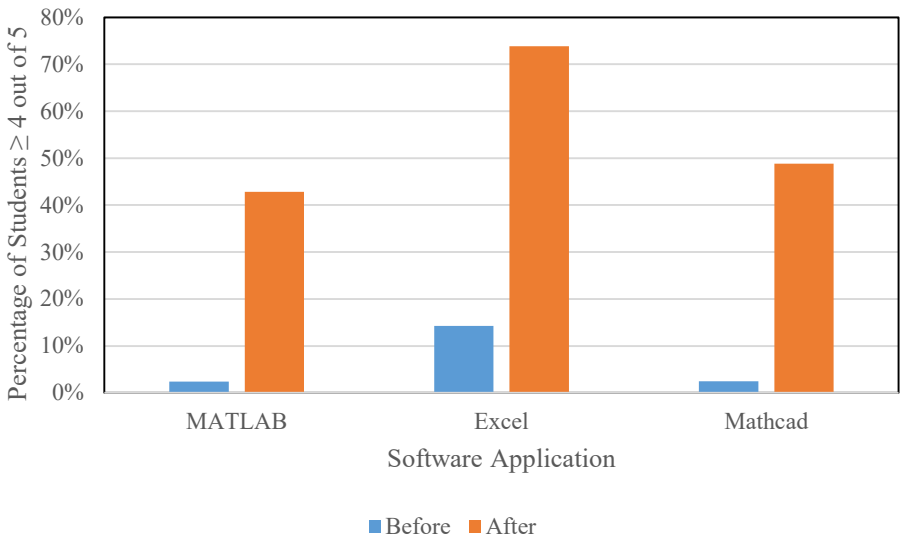


**Figure 4 Percentage of Students who Self-Reported a Skill-Level of 4 or Better**

Of particular importance is the increase in the students' self-reported skill level using Microsoft Excel as the use of this software application was stressed by both alumni and the Professional Advisory Committee. By this metric alone, the course instructors believe that the redevelopment of the course was successful.

## Conclusions

Based on feedback from graduating students, industry representatives, and alumni, an introductory computer programming course was redeveloped. Through a senior exit-survey, it was found that 28% of graduating students self-reported their skill level regarding computer programming at a level of below average or poor. However, upon surveying alumni, approximately 65% of alumni reported that their current position did not require the use of computer programming. In support of this, members of the program's Professional Advisory Committee indicated that the students whom they employed rarely required the use of computer programming. As such, the representatives from industry recommended that the introductory computing course be revised to focus more on the use of spreadsheet tools. In good agreement, 100% of the alumni surveyed indicated that they utilized spreadsheet tools in their current positions. Therefore, the introductory computing course was revised to meet the needs of its constituents and now covers spreadsheet tools in Microsoft Excel, engineering calculations in PTC Mathcad, and computer programming in MATLAB. Through a survey distributed at the end of the course's first offering, 74% of students self-reported their skill level utilizing Microsoft Excel as "Very Good" or better.

## References

1 Chapman, Stephen, MATLAB Programming for Engineers, Cengage Learning, Boston, 2016.

2 Gottfried, Byron, Spreadsheet Tools for Engineers Using Excel, McGraw-Hill, New York, 2019.
3 Palm, William, MATLAB for Engineering Applications, McGraw-Hill, New York, 2018.
4 Maxfield, Brent, Essential Mathcad for Engineering, Science, and Math, Elsevier, Burlington, 2009.
5 Pritchard, Philip, Mathcad: A Tool for Engineering Problem Solving, McGraw-Hill, New York, 2011.
6 Maxfield, Brent, Engineering with Mathcad: Using Mathcad to Create and Organize your Engineering Calculations, Elsevier, Burlington, 2006.

## David Calamas

David Calamas is an Assistant Professor in the Department of Mechanical Engineering at Georgia Southern University. He currently teaches undergraduate and graduate lecture and laboratory courses in the areas of fluid mechanics, thermodynamics, and heat transfer. He currently conducts research in the areas of active and passive thermal management, thermal and fluid transport processes, biologically-inspired designs, and engineering education.

## Aniruddha Mitra

Aniruddha Mitra is a Professor in the Department of Mechanical Engineering at Georgia Southern University. He is a licensed Professional Engineer and an Affiliate Director for Project Lead the Way. He currently teaches in the areas of numerical methods, vehicle dynamics, and engineering mechanics. He currently conducts research in the areas of composite materials, instrumentation, and vibration analysis of mechanical systems.

## Brian Vlcek

Brian Vlcek is Professor and Chair of the Department of Mechanical Engineering at Georgia Southern University. He currently serves as the campus representative for the Southeastern Section of ASEE. He has conducted research in the areas of cryogenic turbopump seals, vapor lubrication of high-temperature contacts, fatigue failure of PVC coatings, probabilistic modeling of fatigue failure, aluminum fatigue failure and analysis, and engineering education.