Incorporating Graphical User Interface (GUI) Design Component in Engineering Curriculum

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Abstract – The knowledge of Systems Engineering (SE) is increasingly valued by the engineering community. An important aspect of SE is human factors, i.e., design for usability. User-friendliness has always been an essential measure of product quality. For many engineering products, customers' paramount concern is ease of use. It is our belief that engineering students should establish such a mindset and possess relevant skills to develop user-friendly products. However, there is not enough emphasis in this area in the current engineering curriculum. This paper describes our recent efforts in addressing the above issue by incorporating Graphical User Interface (GUI) design component in engineering courses at Embry-Riddle Aeronautical University (ERAU). A GUI is a pictographic interface that makes software programs and computer controlled devices easy to use by providing consistent appearance and intuitive controls like push buttons, list boxes, slider, menus, etc. The concepts and basic steps to create GUI with MATLAB are introduced in two engineering classes, including Introduction to Computing for Engineers, and Electrical Engineering I. Then, we assign students projects to design simple GUIs to perform functions related to course materials. For example, students in Electrical Engineering I design a GUI to convert complex-valued numbers between polar and rectangular forms. The GUI can be used to solve AC circuit homework problems, which significantly reduces the amount of calculation performed by hand. Additional assessment is performed through an end-of-course survey. This new teaching practice was well received by engineering students. It not only increased their awareness of user-friendliness for engineering products, but also improved their confidence in working with computer software to solve engineering problems. It is our belief that the benefit of such practice will well extend into students' future professional career.

Keywords: Graphic User Interface, MATLAB, User-friendliness

INTRODUCTION

The knowledge of systems engineering is increasingly valued by the engineering industry, as evidenced by employment statistics and comments from Industrial Advisory Boards (IAB) of engineering schools. There has been clearly a need to enhance systems engineering curriculum in undergraduate engineering education. One of the essential aspects of systems engineering is human factors, i.e., design for usability. For the engineering profession, one of the most essential measures of product quality is user-friendliness. In many applications, customers' paramount concern is whether the engineering product is convenient to use. It is our belief that engineering students should establish such a mindset as early as possible and possess relevant engineering skills to develop user-friendly products. However, there is not enough emphasis in this area in the current engineering curriculum.

This paper describes our efforts in addressing the above issue by incorporating Graphical User Interface (GUI) design component in two engineering courses. Our objective is to educate the students the importance of user-friendliness for engineering products, and at the same time equip them with relevant computer skills in their college

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education. It is our belief that the benefit of such teaching practice will well extend into students' subsequent years in college and future professional career.

GUI is an interface that allows people to conveniently interact with a computer and computer-controlled devices. Previously, MATLAB-based GUI component has been incorporated in control system courses [1-4]. It has been shown that MATLAB's powerful tools can give the instructor the ability to create educational tools not only for control systems but also for many other majors, with moderate coding, using appropriate MATLAB built-in functions.

In our efforts, the GUI components are adopted in two courses, EGR 115: Introduction to Computing for Engineers, a freshman engineering course introducing MATLAB and C programming; and EE 335: Electrical Engineering I, an introductory circuit analysis course taken by junior and senior engineering students. The concepts and basic steps to create GUI with MATLAB are introduced in these classes, and the students are then assigned simple projects to practice the skills with typical engineering applications appropriate to the course content. Assessment is performed through homework assignments, course projects, and an end-of-course survey. The assessment data indicate that this teaching practice is well received by students, and it has the potential to enhance student learning of relevant engineering concepts in upper level courses. (Discussions of assessment are included in the "Outcome, assessment and dissemination" section.)

DESCRIPTION OF THE NEW TEACHING PRACTICE

A GUI is a pictographic interface to a program that makes software programs easier to use by providing users with consistent appearance and intuitive controls like push buttons, list boxes, slider, menus, etc. GUIs offer a visual approach to problem solving. A well-designed GUI behaves in an understandable and predictable manner, so users know what to expect when an action is performed. For example, when a mouse click occurs on a pushbutton, the GUI should initiate the action described on the label of the button. In addition, a "what-if" attribute can be added to provide capabilities of changing the problem parameters and presenting the effects graphically. This feature can further facilitate the discussion in a classroom environment, and also help students further explore the effects of different parameters and their interactions in complex problems.

Building GUIs in MATLAB environment has been simplified significantly in MATLAB version 7.1, which we have on the ERAU campus. There are a set of convenient tools in MATLAB 7.1 that make building GUIs easy and fast. In our efforts, we teach students these easy-to-use tools, including: 1) Graphical Components: push button, labels edit box, check box, pop-up menu, slider, and list box; 2) Figures: components arrangement within a window on the computer screen; 3) Callbacks: methods to cause the execution of actions when the user clicks on a button or types information from the keyboard.

For EGR 115 course (Introduction to Computing for Engineers), students first study the basics of MATLAB, and then they are introduced the above mentioned GUI tools in class. Afterwards, they are assigned small-scale projects to design GUIs that implement some frequently encountered operations in engineering, such as: 1) converting temperature from degrees in Fahrenheit to degrees in Celsius and vice versa over range 0-100 C. with GUI accepting user inputs and displaying the results; 2) converting various other values between the English and Metric systems with GUI accepting user input and displaying results; 3) converting from rectangular-form complex numbers to the corresponding polar-form and vice versa with GUI accepting user input and displaying results numerically and graphically; and 4) solving system of linear equations and display solutions.

For each project, students are asked to 1) determine required elements and the function each element will perform as well as make a rough layout of the components by hand on paper; 2) layout the components on a figure in MATLAB; 3) use alignment tool to adjust the alignment and spacing of components; 4) use property editor to set the characteristics of each component, such as color and text; 5) define a callback function for each element as necessary and use property editor to store the names of appropriate callback functions; and 6) write the callback functions to control the GUI in response to user actions.

In EE 335 (Electrical Engineering I), emphasis is on the use of GUI to facilitate the solution of circuit problems. Specifically, there are two topics that directly benefit from the introduction of GUI: solving linear systems of equations resulted from nodal analysis and mesh analysis of DC circuits, and conversion of complex numbers between rectangular and polar forms in AC circuit analysis. These two topics are often considered by most students

as tedious and difficult, so students especially appreciate the assistance of computer software in the problem solving process.

After introducing the concepts and basic steps to create GUI with MATLAB, students are required to create two simple GUI performing the solution of linear systems of equations, and conversion of complex-valued numbers between rectangular and polar forms, respectively. The developed GUI will then be used to solve DC and AC circuit problems in homework assignments. Also, students are encouraged to verify the consistency of computer generated answers with theoretical results obtained by hand calculations.

In both courses, students are encouraged to use their unique styles and creative talents, since creativity and innovation are important in GUI design.

OUTCOME, ASSESSMENT AND DISSEMINATION

Our proposed teaching practice has the following potential benefits to students:

1. Awareness of the importance of user-friendliness in engineering product design;
2. Ability to group and classify the functions of a system as well as its inputs and outputs.
3. Confidence in the use of computer software for engineering products, and the understanding of strengths and limitations of computer tools;
4. Ability to verify the consistency of computer generated data with theoretical results;
5. Ability to communicate important information effectively through the design of GUIs and written project reports;
6. Useful programming skills for design projects in subsequent engineering courses and senior design;
7. Practical experience in the holistic approach for design problems and enhanced interests in the engineering profession.

Of equal importance is our purpose to inspire students to take the initiative to internalize the knowledge they learned in classroom. We believe student motivation is an essential indicator of the success of any new teaching practice in STEM disciplines, and retention rate in these disciplines heavily depends upon students' perception on how much useful skills they obtain in classroom.

After we incorporated GUI components in the two courses in 2009, students responded very positively to the new teaching practice, and many expressed their appreciation to instructors. In EGR 115, a project-based programming course, many students elected to design GUIs for their projects in addition to GUI assignments, though it was not required by the instructor. The collected GUI assignments clearly indicated that most students put in much effort in designing GUIs, and they wanted to showcase their unique styles and talents through such design process. To further obtain more assessment data concerning students' interests and motivation towards GUI design component in engineering curriculum, we conducted a survey to assess students' subjective opinions and solicit their comments. The survey contains ten statements describing the potential benefits and outcomes of the new teaching practice, and for each statement, students are asked to provide a score ranging from 1 to 5, with 1 being "strongly disagree" and 5 being "strongly agree". At the end of the survey, an open-ended question is asked to solicit students' suggestions on ways to further improve GUI design instruction in the future.

The statements in the survey include:

1. User-friendliness is important for engineering products.
2. A properly designed GUI can increase the efficiency of engineering design.
3. In GUI design assignments, I can properly group and classify the functions of a system as well as its inputs and outputs.
4. In GUI design assignments, the results I got from GUI are consistent with theoretical results obtained by hand calculation.
5. The GUI I designed is easy to use.
6. My programming skills are improved through GUI instruction and assignments.
7. It is beneficial to incorporate GUI instruction in engineering courses.
8. Computer software is useful in engineering design process, but it also has its limitations.
9. I am interested in knowing more about GUI design by MATLAB in the future.
10. GUI instruction and assignment should be incorporated into engineering design courses.

The survey results are overwhelmingly positive. Students clearly realize the importance of user-friendliness and the value of GUI in engineering product design. In particular, 100% of the students believe GUI can increase the efficiency of engineering design (question 2), and all students are interested in learning more about GUI design in the future (question 9). In addition, all students believe GUI components should be incorporated into engineering design courses wherever possible (question 10).

For the open-ended question, many students indicated that visualization is important to their learning, and GUI undoubtedly helps them to understand relevant course contents.

To promote the new teaching practice to other faculty members in the university, we made a poster presentation at a faculty forum organized by ERAU Center for Teaching and Learning Excellence. The forum was attended by all ERAU faculty members, and our presentation summarized the GUI instruction materials, objectives and assessment of the new teaching practice, and a discussion of the outcomes and advantages of our experiments.

CONCLUSIONS

In this paper, we described our recent attempt to increase the awareness of engineering product user-friendliness among engineering students through the incorporation of GUI design components in engineering curriculum. Our initial experiment was conducted in one freshman programming course and one upper level circuit analysis course. After giving introduction of basic GUI design process in MATLAB, the instructor assigns students to design simple GUIs that perform calculations relevant to course materials in a user-friendly manner. The new teaching practice was very well received by engineering students with enthusiasm, as evidenced by student survey results. The benefits of the teaching practice also includes, increasing students' understanding of the advantages and limitations of computer tools, cultivating students' communication skills through GUI design, improving students' programming skills, and enhancing students' interests in the engineering profession, etc.

Our experiment was presented to other faculty members in the university, and the new practice is currently being adopted in multiple sections of both courses. In the future, we plan to promote the GUI instruction in more engineering courses, and disseminate our experimental results among colleagues at other engineering schools.

ACKNOWLEDGMENT:

The proposed teaching practice was supported by an ERAU Assessment Grant Project.

REFERENCES

[1] R. DeMoyer, E. E. Mitchell, "Use of the MATLAB graphical user interface development environment for some control system applications," *The 29th Frontiers in Education Conference*, vol. 2, pp.12B3/7-12B3/11, 1999.

[2] S. Lee, Y. Li, V. Kapila, "Development of a Matlab-Based Graphical User Interface Environment for PIC Microcontroller Projects", *The 2004 American Society for Engineering Education Annual Conference & Exposition*, 2004.

[3] A. S. Andreatos, A. D. Zagorianos, "Matlab GUI Application for Teaching Control Systems", *The 6th WSEAS International Conference on Engineering Education*, pp. 208-211, 2009.

[4] N. Aliane, "Matlab/Simulink-Based Interactive Module for Servo Systems Learning", *IEEE Transactions on Education*, Volume: 53, Issue: 2, pp. 265 – 271, July 2009.

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