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MATLAB Marina: The Primary Resource for MATLAB in a Freshmen Computing Applications for Mechanical Engineering Course

Dr. Priya T. Goeser, Georgia Southern University

Dr. Priya T. Goeser is a Professor in the Department of Mechanical Engineering, Georgia Southern University - Armstrong Campus in Savannah. She received her Ph.D. in Mechanical Engineering from the University of Delaware. Her current research interests are structural health monitoring, functionally graded materials and innovative teaching methods in engineering education.

Dr. Thomas Murphy, Georgia Southern University

Dr. Thomas Murphy is an Associate Professor of Electrical and Computer Engineering at Georgia Southern University-Armstrong Campus. He received his PhD and M.E. in Electrical and Computer Engineering from the University of Florida and his B.S. in Electrical Engineering from the University of Notre Dame. His research interests are primarily in the areas of digital systems, control systems, signal processing, engineering education, and computer applications in these areas.

Mr. Christopher Williams, Georgia Southern University

Christopher Williams is a Lecturer at Georgia Southern University-Armstrong Campus in Savannah, GA. He received his B.S. and M.S. in Computer Science from Armstrong Atlantic State University. His research interests are primarily in the areas of programming education, mobile computing, and usability. Mr. Williams is a member of the Association for Computing Machinery (ACM).

Dr. David Calamas, Georgia Southern University

Dr. David Calamas is an Associate Professor in the Department of Mechanical Engineering at Georgia Southern University. He received a BS in Mechanical Engineering from Clemson University and a MS and PhD in Mechanical Engineering from The University of Alabama. His research interests are in the areas of biologically-inspired thermal and fluid transport processes, active and passive thermal management, and engineering education. He teaches in the areas of fluid mechanics and heat transfer.

Dr. Junghun Choi, Georgia Southern University

Assistant Professor Department of Mechanical Engineering Georgia Southern University

Work-in-Progress:
MATLAB Marina: The Primary Resource for MATLAB in a Freshmen Computing Applications for Mechanical Engineering Course

Introduction

Current research on the effectiveness of Virtual Learning Environments (VLEs) for teaching programming shows positive results, including the reinforcement of concepts from lectures, exposure to practical applications and problems, and the ability to meet diverse pedagogical needs [1]-[6]. VLEs are used as supplements in courses or in the engineering curriculum to improve students' understanding of fundamental concepts and increase student interest and performance.

This project's primary objective is to transform a first-year mechanical engineering course, Computing Applications in Mechanical Engineering (ENGR 1121) by providing students with a better learning experience and access to inexpensive learning resources (textbook material). The course covers computing applications in Microsoft Excel, MATLAB, and Mathcad. Prior to Spring 2021, the Excel and MATLAB components relied on standard textbooks and the Mathcad portion on instructor notes provided free to students. This project aims to replace the textbook used for the MATLAB portion of the course with free and open resources available online in a Virtual Learning Environment. The MATLAB resources will be available in multiple formats including written text, sample code, multimedia tutorials, and exercises for practice and self-assessment tools. The multiple formats will address the needs of a student body with diverse pedagogical needs.

This VLE will be an enhanced and expanded version of MATLAB Marina – a VLE originally created by the project lead with two team members to replace the textbook in the course Computing for Engineers. This works' impact was significant not only in terms of cost savings for students but also in improving student performance and retention [7]. Student feedback over these semesters consistently showed that students appreciated the cost savings and the online resource instead of a traditional textbook for learning MATLAB. However, after the recent consolidation of two universities the VLE was no longer used as a primary resource due to curricular changes. The computing course prior to consolidation was based solely on MATLAB and targeted a different student body – students in all engineering disciplines, most of whom were intending to transfer to the Georgia Institute of Technology, whereas ENGR 1121 is taken exclusively by Mechanical Engineering students at Georgia Southern University. Based on the success of MATLAB Marina and the availability of this curated content, the original three team members partnered with two faculty members from the Department of Mechanical Engineering on the Statesboro Campus to expand and use this VLE for all sections of ENGR 1121 and replace the current MATLAB textbook.

This work describes students' initial impressions during the period of transitioning from the purchased textbook to using the free online resource for the course. Students were surveyed on their attitudes and perceptions of the purchased MATLAB textbook vs. the free VLE and its usefulness in the course as well as a reference for future classes. The surveys were anonymous and given twice during the semester, when MATLAB is first introduced in the course and at the

end of the MATLAB portion of the course. The surveys included inquiries about study time, specific resource usage, and preferences regarding textbooks versus online materials and consisted of a combination of questions using a Likert scale and written comments. Survey results will be used to improve the VLE for subsequent semesters.

The following sections outline an overview of MATLAB Marina, course description, teaching pedagogy, assessment plans, concluding remarks, and future work.

Overview of MATLAB Marina

MATLAB Marina consists of a main website hosted on a Georgia Southern University server with a domain name www.matlabmarina.com and multimedia tutorials hosted on YouTube with direct links on the site.

The overall structure of the VLE emulates the organization of chapters/topics covered in textbooks used for standard computer science and engineering programming courses [8]-[10]. The three main areas of the VLE are Fundamental Programming Concepts, Advanced Programming Concepts, and Applications as is shown in the screenshots in Figures 1-2. Each of these areas consists of several learning modules with each module consisting of one or more primers, multimedia tutorials, sample programs, and practice exercises.

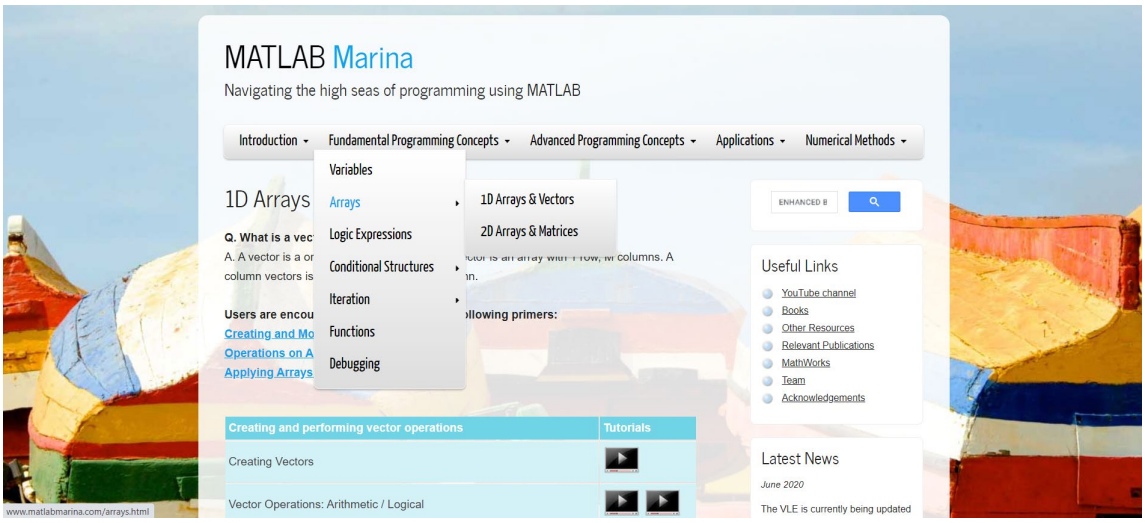

Figure 1: Screenshot of the module on 1D Arrays on MATLAB Marina

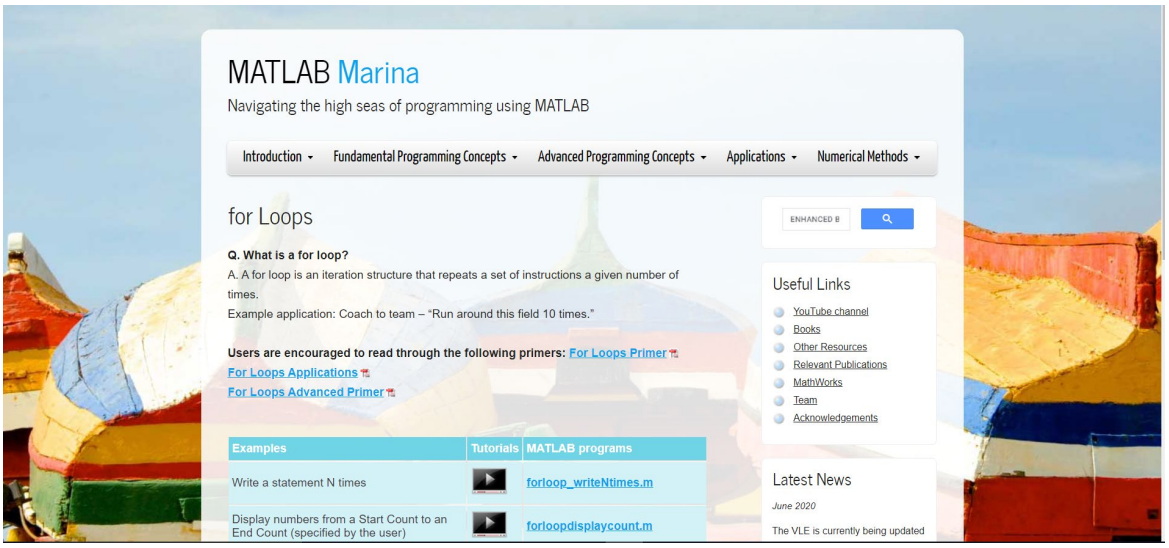

Figure 2: Screenshot of the module on for Loops on MATLAB Marina

Course Description

The course Computing Applications for Mechanical Engineers (ENGR 1121) is a 2-credit hour course taken by mechanical engineering majors at Georgia Southern University. It is intended for students to develop their technical computing skills using current and widely used platforms in the professional world. Standard mathematical functions and applications including logical expressions, data input/output, arrays, and statistical functions are introduced. Specific mechanical engineering software applications such as Microsoft Excel, MATLAB, and Mathcad are utilized to introduce students to problem-solving logic, flow charting, and programming.

The pre-requisites/co-requisites for the course are either College Trigonometry, Pre-calculus, or Calculus I. The course serves as a first course in computer programming for mechanical engineering students and most students are challenged by the course. Student performance and learning is clearly a problem based on historical grade data and observation. Students typically have a more challenging time understanding and applying traditional programming constructs such as arrays, loops, and structures than they do with some of the specific applications such as plotting and numerical methods. In addition, students are not prepared for the rigorous, consistent work that is required for such a course. It is proposed that MATLAB Marina can be used as an effective resource to help address these challenges and improve student learning.

Teaching Pedagogy

At Georgia Southern University, ENGR 1121 is a semester long course and is taught in a studio format, laboratory only course with no separate lecture component, and meets for 100 minutes twice a week in a computer lab. While the lab sessions allow for hands-on work, there is little time for in-class lecture from the instructor. Typically, a short 8-10 minute lecture is given by the instructor at the beginning of each lab and students spend the rest of the lab session working on programs. When covering some of the traditionally more difficult topics, a second or third 5-10 minute lecture is given at various intervals during the lab. Hence, the class is ideally a

mixture of short lectures and in-class exercises illustrating the concepts and applications of the concepts. This use of active learning has been found to be effective in the instruction and learning of programming concepts [11].

In Fall 2020, students in one section of the course used the VLE in lieu of the textbook for the MATLAB portion. In Spring 2021 all sections of the course used the VLE for the MATLAB portion, though three of the four instructors used it more intentionally. Overall, the use of MATLAB Marina in ENGR 1121 was beneficial for faculty and students. Students had access to multiple examples, some of which were explained using a step-by-step video tutorial, while others were explained within the primers, and others were included as a supplement to the primers. When examples are made available in multiple formats, students are more willing to take the initiative to learn and master the concepts rather than simply rely on the support from the instructor and tutors or friends/peers. For instance, there are certain concepts such as 'using a for loop for a running sum' which are challenging for most students and in the past instructors have had to explain this concept multiple times using multiple formats or sometimes even have to repeat these explanations. Now, instructors could introduce the concept and point the students to the other examples, which students can watch/read at their own pace and multiple times if needed. Hence, instructors were able to spend more in-class time helping students understand the application of concepts and debug their programs.

The use of the VLE also encouraged students to come prepared to class. Outcomes were assessed using completed class exercises and projects along with in-class exams. This type of instruction encourages student ownership and participation in their learning outcomes (a metacognitive approach [12]-[13]).

Assessment Plans

The average enrollment for the course is approximately 270 students per academic year. However, under COVID-19 restrictions enrollment has been significantly lower for the 2020-2021 academic year. While only one small section of the course used the VLE in Fall 2020, all sections of the course used it in Spring 2021 with a total enrollment of 124 students (normally enrollment is around 175 in the spring semester).

In Spring 2021, when the VLE was used across all sections of ENGR 1121, students were given a pretest near the beginning of the semester and a posttest near the end of the semester. The tests consisted of the same questions presented in the same order. The average score for the pretest was 52.6% while the average score of the posttest was 75.0%. Therefore, an increase in student performance was recorded. In Fall 2020, 15 of 58 (25.86%) of students dropped, withdrew, or failed the course. In Spring 2021 with the use of the VLE, 22 of 124 (17.74%) students dropped, withdrew, or failed the course.

Surveys were given to students to complete anonymously to determine their attitudes and perceptions of using a traditional textbook versus the VLE as their main instructional resource. Other than the anticipated low to no cost perspectives, a couple of other advantages noted by students were: easily searchable material and no added weight that they would need to carry around every day. A sample set of results from the survey are shown in Figure 3. As also

observed, overall students either strongly agreed or agreed that the examples on the VLE were clearly explained.

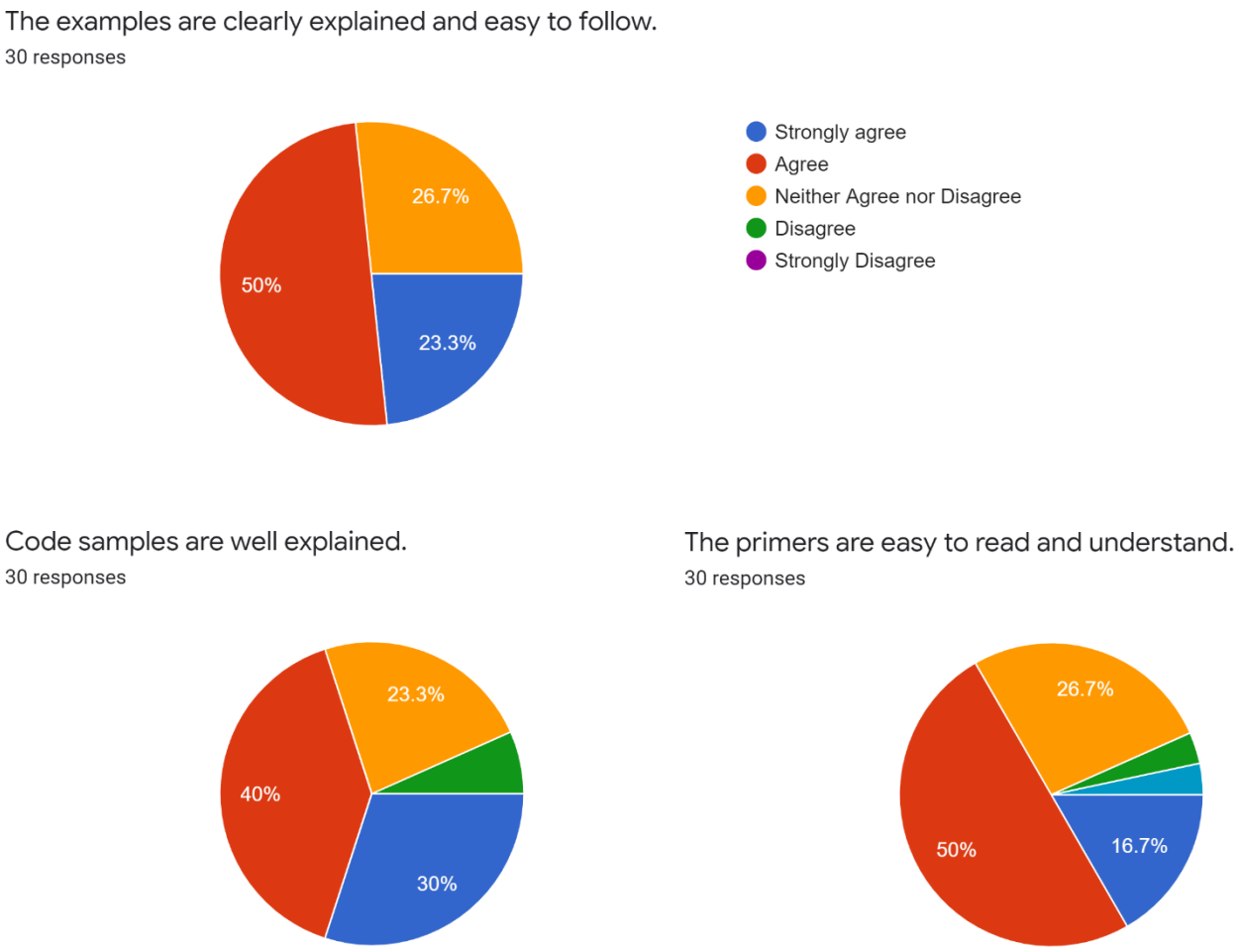

Figure 3: A sample survey result from Spring 2021

During the Fall 2020 semester where the VLE was used in one section, Google Analytics data shows that there were 152 users, 167 sessions, and 507 pageviews. User locations were reported from across the globe, with 35% (53) of them being from the United States. Expanding that out to calendar year 2020 shows 576 users, 691 sessions, and 1,843 pageviews. Content-wise, both of those periods show almost identical usage patterns with "Fundamental Concepts" "Introduction to MATLAB," "for loops," "Variables," "1D Arrays," and "2D Arrays" showing up in the top 10 most viewed pages. Those topics, in particular, are taught in the ENGR 1121 course.

In Spring 2021 where the VLE was used in all four sections, Google Analytics data becomes heavily unreliable showing only 14 users, 28 sessions, and 87 pageviews. Considering that all four sections were using the VLE, the authors assumption is that something changed in the Google Analytics tracking that went unnoticed until after the pandemic. Considering the

statistics from previous semesters and personal testing, there do seem to be some issues with the tracking registering users and pageviews. The authors have identified at least two possible contributing causes: 1) a new version of the tracker that was waiting on being updated until the summer to avoid tracking issues and/or 2) browser-based ad-blocking software has seemingly added Google Analytics as a blockable source. The plan in the summer is to update the tracking and test the functionality to hopefully make up for this unfortunate loss in usage data.

YouTube Analytics is used to track all the video tutorials on MATLAB Marina. There was a total of 39,841 views in Fall 2020 with 9,868 views (24.8%) of them being from the United States. In 2021, the results are similar with a total of 38,298 views with 9,253 (24.2%) of them being from the United States.

Concluding Remarks and Future Work

MATLAB Marina was initially developed to be the primary resource in a Computing for Engineers (ENGR 1371) course at Armstrong State University. Over the past year, the VLE was re-structured and expanded to be used as the primary resource for MATLAB in a Computing Applications for Mechanical Engineers (ENGR 1121) course at Georgia Southern University. While Spring 2021 is the first semester for this implementation, preliminary comments from its limited use in Fall 2020 and from the current students are positive. The VLE is well received, being used by students, and the overall lack of a primary textbook does not prove to be detrimental to student performance and learning.

VLEs such as MATLAB Marina provide instructors with the option to teach programming using the flipped classroom model. However, this model requires greater student ownership and responsibility in preparing for the lectures before coming to class. Thus, it requires students to be motivated and engaged, which can be a challenge for freshmen level students.

Pedagogically, MATLAB Marina represents current trends in education where traditional courses are blended with online learning environments to meet the needs of the next generation. This paper is a presentation of the current Work-in-Progress. Current and future work includes extensive assessment of the efficacy of the VLE. After 2-3 semesters of implementation, assessment can also include how well students are retaining the concepts learned in this course for subsequent courses in the curriculum. Since a VLE such as this one is based completely online, it can serve as a useful reference for courses later in the curriculum as well.

Acknowledgements

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