The Effective Use of Virtual Learning Environments like MATLAB Marina as the Primary Resource for an Introductory Programming Course

Priya T. Goeser\textsuperscript{1}, Thomas Murphy\textsuperscript{2}, Christopher Williams\textsuperscript{3} and Wayne M. Johnson\textsuperscript{4}

Abstract – Most engineering curriculums include an introductory programming course and many use MATLAB, a technical computing language. Teaching students to become competent and efficient programmers continues to be a challenge. MATLAB Marina, a Virtual Learning Environment (VLE) developed by faculty and staff at Armstrong Atlantic State University, is dedicated to the improvement of student learning of programming concepts using MATLAB. It consists of learning modules which cover fundamental to advanced programming concepts and applications. Each learning module has primers that review algorithmic concepts, terms, MATLAB syntax and examples, multimedia tutorials that reinforce the algorithmic concepts using MATLAB syntax, and practice exercises. Computing for Engineers is a course that introduces students to the foundations of computing and the development of programs for solving engineering problems using MATLAB. This work presents a preliminary investigative study exploring the use of this VLE as the primary resource in this course.

Keywords: MATLAB, Introductory programming course, virtual learning environment

INTRODUCTION

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

MATLAB Marina is a VLE developed by faculty and staff at Armstrong Atlantic State University (Armstrong). The VLE is dedicated to the improvement of student learning of programming concepts using MATLAB and consists of about 35 learning modules which cover fundamental to advanced programming concepts and applications. Each learning module has primers that review algorithmic concepts, terms, MATLAB syntax and examples, multimedia tutorials that reinforce the algorithmic concepts using MATLAB and practice exercises. MATLAB Marina was developed based on the premise that by incorporating it into the instruction of a traditional programming course, students can use online environments to enhance their understanding of programming concepts and their application to real-world problem solving, which will improve their learning and overall performance. The initial prototype of the VLE was developed in Fall 2011 and consisted of a set of tutorials that covered a range of fundamental programming concepts. Assessment studies from Fall 2011 to Spring 2013 showed

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that these tutorials were used extensively and improved student learning [7]-[8]. However, the VLE needed to be enhanced to include modules covering more programming concepts and applications to be more effective for student learning and performance. In addition, it was found to be imperative that the VLE be effectively integrated into the curriculum of the course since the existence and availability of such tools does not necessarily guarantee their use by students for learning. Hence, this work presents the re-structuring and development of MATLAB Marina to include modules that not only cover a wider range of programming concepts and applications, but also expand the modules to include primers, tutorials and exercises. The VLE could then serve as the primary resource in an introductory programming course.

Computing for Engineers (ENGR1371) is a 3-credit hour course taken by all engineering students at Armstrong. The main objective of the course is to introduce students to the foundations of computing with an emphasis on the design and analysis of algorithms and development of programs for solving engineering problems using MATLAB. Many students struggle to successfully complete courses such as ENGR1371. The combination of traditional introductory programming concepts along with exposure to engineering applications makes for an intensive programming course. The instructors often need to make a trade-off between covering programming concepts in depth and covering specific applications that will be used in subsequent engineering courses. One approach to this challenge is the flipped classroom model where by students are expected to review course materials before class and the class time is used for hands-on exercises [9]. It is proposed that MATLAB Marina can be used as an effective primary resource (in lieu of a textbook such as [10]-[12]) to help address this challenge and improve student success. This paper presents a preliminary investigative study exploring the various challenges of using MATLAB Marina as the primary resource in ENGR1371. Student surveys and performance (current and previous semesters) along with tracking data of the VLE are analyzed with the objective to understand the following pertinent questions:

- To what extent does the lack of a primary textbook influence student performance and learning?
- What impact does MATLAB Marina have on student performance and learning?
- What are some effective ways to use VLEs such as MATLAB Marina and how does this influence course design and delivery?

The following sections outline a detailed overview of MATLAB Marina, course description including the teaching pedagogy, assessment results and concluding remarks and future work.

### Overview of MATLAB Marina

MATLAB Marina consists of a main web-site hosted at Armstrong [13] and multimedia tutorials hosted on YouTube (channel matlabmarina [14]). Table 1 shows the re-structured VLE which currently emulates the organization of standard computer science and engineering programming courses. The three main areas of the VLE are Fundamental Programming Concepts, Advanced Programming Concepts and Applications. Each of these areas consists of several learning modules with each module consisting of a primer, multimedia tutorials, sample programs, and practice exercises. As indicated in the table, all learning modules except for those that are labeled as TBD (To Be Done) have been completed.

**A. Fundamental Programming Concepts:** The 11 learning modules covered under Fundamental Programming Concepts introduce concepts from Variables, Arrays, Logic Expressions, Conditional Structures, to Iteration and Functions. A major component of the course ENGR1371 is the fundamentals of algorithm development and programming with about 50% of the time spent on covering the fundamentals of programming concepts. Since these concepts provide the foundation for problem solving and other applications, it is crucial for students to develop a thorough grasp of this material. A significant portion of the students at Armstrong (25-30%) drop the course during this time with several others losing confidence and/or interest as they view this as an abstract collection of concepts, with little or no application. Hence, the modules in this area are extensive. The concepts in these modules are illustrated using mathematical and engineering applications such as the path of a projectile motion, sum of terms in a series, etc.

**B. Advanced Programming Concepts:** There are eight learning modules covered under Advanced Programming Concepts including concepts that are typically part of the first or second course in scientific programming such as searching and sorting. Several of the concepts in these learning modules are illustrated using applications that involve processing collections of data.
C. Applications: This third area is where students learn how to apply programming to solve specific problems. This area consists of 16 learning modules with two on Plotting, nine on various Numerical Methods, and a couple on specific applications in engineering such as Statics and Thermodynamics. While the students are introduced to plotting, basic Numerical Methods, Image and Sound Processing in this course, many of the advanced topics in these modules are addressed later in courses such as Statics (ENGR2001), Dynamics (ENGR2202), Computational Modeling (ENGR2010), and Introduction to Signal Processing (ENGR2025).

In addition to these 35 learning modules, the VLE includes modules on Introduction to MATLAB and Algorithm Development I (both housed under a broader area aptly named as Introduction). These modules are designed to introduce students to the MATLAB interface and basic algorithm development. Note that the organization of the VLE is intentionally similar to the chapters/topics covered in most textbooks used for this and similar programming courses.

<table>
<thead>
<tr>
<th>Introduction to MATLAB Algorithm Development I</th>
<th>A. Fundamental Programming Concepts</th>
<th>B. Advanced Programming Concepts</th>
<th>C. Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>Characters and Strings</td>
<td></td>
<td>Plotting</td>
</tr>
<tr>
<td>Arrays</td>
<td>Cell Arrays</td>
<td></td>
<td>2D Plotting</td>
</tr>
<tr>
<td>1D Arrays and Vectors</td>
<td>Structures</td>
<td></td>
<td>3D Plotting</td>
</tr>
<tr>
<td>2D Arrays and Matrices</td>
<td>Recursion (tutorials only)</td>
<td></td>
<td>Numerical Methods</td>
</tr>
<tr>
<td>Logic Expressions</td>
<td>Exception Handling (TBD)</td>
<td></td>
<td>Linear Algebraic Equations</td>
</tr>
<tr>
<td>Conditional Structures</td>
<td>File Input / Output</td>
<td></td>
<td>Data Statistics (TBD)</td>
</tr>
<tr>
<td>If-else-end statements</td>
<td>Sorting</td>
<td></td>
<td>Curve fitting</td>
</tr>
<tr>
<td>Switch-case statements</td>
<td>Searching</td>
<td></td>
<td>Interpolation (no tutorials)</td>
</tr>
<tr>
<td><em>Iteration</em></td>
<td></td>
<td></td>
<td>Integration</td>
</tr>
<tr>
<td>For Loops</td>
<td></td>
<td></td>
<td>Differentiation</td>
</tr>
<tr>
<td>While Loops</td>
<td></td>
<td></td>
<td>Roots of Equations</td>
</tr>
<tr>
<td>Functions</td>
<td></td>
<td></td>
<td>Ordinary Differential Equations (TBD)</td>
</tr>
<tr>
<td>Debugging</td>
<td></td>
<td></td>
<td>Optimization (TBD)</td>
</tr>
<tr>
<td>Algorithm Development II (TBD)</td>
<td></td>
<td></td>
<td>Image Processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sound Processing (no tutorials)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GUI (TBD)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Statics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Thermodynamics (TBD)</td>
</tr>
</tbody>
</table>

Table 1: Organizational Structure of MATLAB Marina

Pedagogy of the Learning Modules

Each learning module is designed to encompass the following through relevant content items:

i. Primers: Each learning module has a primer (3-12 pages) that introduces the core programming concepts, terms and MATLAB commands for the module. The primer includes implemented program examples that illustrate applications of the concepts and the use of the many built in MATLAB functions. It is expected that students will read the primers as a pre-instructional reading assignment prior to the introduction of each module in class. The primers are laid out similar to textbook sections/chapters and time students previously spent reading the textbook would now be spent reading the primers.
ii. Multimedia Tutorials: Each learning module has 3-6 multimedia tutorials which help to reinforcement concepts introduced in the primers. The tutorials are designed to address the visual, auditory and typographical aspects of learning with dynamic callouts and workspaces, captions and audio explanations. Each tutorial begins with a brief introduction of the topic being covered (< 0.5 minute), followed by a step-by-step explanation of the algorithm and the corresponding MATLAB code (2-3 minutes), and a summary of the concept/topic (< 0.5 minute). This instructional pedagogy is adapted from a modular programming strategy in which students learn how to solve a complicated problem by dividing it into small steps and addressing each step by a programming procedure illustrated using flow charts [15]. The tutorials are designed to illustrate the concepts in each learning module using relevant engineering or mathematical applications. All excerpts of MATLAB code or programs shown in the tutorials are also made available via links on the module web-page.

iii. Exercises: Exercises that test the concepts learned are included for each module. The exercises involve solving problems by writing short MATLAB code segments, MATLAB functions, and more involved MATLAB programs. The exercises build from relatively straightforward problems to more challenging problems. The exercises are designed to encourage proper programming style, solving more complicated problems in steps, program code modification and reuse, and debugging/testing. These exercises are currently used as self-assessment tools and not graded. The primary purpose of these is to encourage students to become familiar with MATLAB’s syntax and interface by becoming active learners (learning by doing) and gain additional experience in writing and testing programs to solve problems.

COURSE DESCRIPTION

Computing for Engineers (ENGR1371) is a 3-credit hour course taken by engineering majors and as a computing course requirement by mathematics and applied physics majors at Armstrong. Currently the average enrollment for the course is 100 students per year of which about 65% successfully complete the course (with a grade of C or better). Student performance and learning is clearly a significant problem. Students typically have a harder 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 Armstrong, ENGR1371 is a semester long course (16 weeks) and meets either three times a week for 50 minutes each meeting or twice a week for 75 minutes each meeting. For the past few years, the primary instructors for the course (the authors) have taught the course using 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 [16]. Students were also expected to initially gain exposure to each topic through reading their textbook [10] and posted notes/slides. These topics were then reinforced in class with short lectures (5-10 minutes) followed by in-class programming exercises. Students were required to purchase a copy of the textbook with a recommendation to purchase a copy of the student version of MATLAB. According to a survey of students from these past semesters, 32.1% (from a sample size of N=28) purchased/rented/borrowed a textbook, 7.1% purchased the software only and 57.1% bought both the textbook and the software when they took the course. Note that further details from this survey are presented in the next section on Assessment.

In Fall 2013, students were required to purchase the student version of MATLAB and the VLE MATLAB Marina served the role of the textbook. The primers and tutorials on MATLAB Marina were incorporated as the pre-instructional reading material (in lieu of the textbook and class notes). Students reviewed important terms and useful MATLAB commands before they came to class and were often tested with an in-class and/or online quiz on the basic content in the module. This not only encouraged students to come prepared to class, but also allowed the instructors more in-class time for hands-on programming sessions. In addition, students learned to develop and debug programs by completing the practice exercises along with individual and group programming projects. Outcomes were assessed using completed class exercises and projects along with quizzes and exams. This type of instruction requires students to be prepared for class, hence encouraging student ownership and participation in their learning outcomes (a metacognitive approach [17]-[18]).
To assess the effectiveness of MATLAB Marina, surveys were given to students (those in current sections of ENGR1371 and those who have taken it in the past few semesters at Armstrong) to complete and return anonymously. Current students were given an initial survey during the second week of the semester and an end of semester survey during the last week of the semester. Past students were given a single survey. While the surveys given to both groups of students were similar, the questions for the past students were asked in a manner such as ‘If you had the recent version of MATLAB Marina available to you when you took ENGR1371…’ with an acknowledgement that some of them had no such resource while others had access to the initial prototype of the VLE as developed in Fall 2011. Summaries of the results of this survey are provided in Tables 2 through 4.

It is observed from the initial survey results, that 85.5% of the students taking ENGR1371 in Fall 2013 agreed (somewhat to a great deal) that the resources on MATLAB Marina did offer them great flexibility to learn the way they want. This increased to 100% in the end of semester survey. In addition, a majority of respondents, 76.5%, agreed that the resource made their study time more efficient and 82.4% agreed that the VLE increased their engagement with the course content. This increased to 100% and 92.3% respectively in the end of semester survey.

Addressing the specific resources comprising MATLAB Marina, 85.3% found the primers useful, 82.4% found the tutorials useful, and 91.2% found the exercises useful. However, it is interesting to note that while 82.4% of the current students say that they completed 60% or more of the primers, only 55.9% and 67.7% say that they completed 60% or more of the tutorials and exercises respectively (in spite of the fact that weekly quizzes were given based on this material). In the end of semester survey the percentages of students finding the primers, tutorials, and exercises respectively increased to 100%, 83.3%, and 83.3% respectively. The percentage of students reading 60% or more of the primers increased to 91.7%; however, the percentage of students reading 80% or more of the primers decreased to 25%. In addition, in the end of semester survey 30% and 58.3% of students completed 60% or more of the exercises and tutorials respectively.

### Table 2: Comparison of Learning Needs

<table>
<thead>
<tr>
<th>Questions</th>
<th>Responses</th>
<th>Fall 2013 (initial) # of responses (% of N=34)</th>
<th>Fall 2013 (end of semester) # of responses (% of N=13)</th>
<th>Past Students # of responses (% of N=27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compared to the ‘normal use of textbooks’ to what extent are your learning needs met by the resources on MATLAB Marina?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Offers greater flexibility to learn the way I want (resources are accessible online 24/7, can be downloaded and used at a convenient time, place, format, etc.)</td>
<td>Not at all</td>
<td>1 (2.9%)</td>
<td>0 (0%)</td>
<td>1 (3.7%)</td>
</tr>
<tr>
<td></td>
<td>A little</td>
<td>4 (11.8%)</td>
<td>0 (0%)</td>
<td>2 (7.4%)</td>
</tr>
<tr>
<td></td>
<td>Somewhat</td>
<td>8 (23.5%)</td>
<td>1 (7.7%)</td>
<td>6 (22.2%)</td>
</tr>
<tr>
<td></td>
<td>Quite a bit</td>
<td>11 (32.4%)</td>
<td>7 (53.8%)</td>
<td>9 (33.3%)</td>
</tr>
<tr>
<td></td>
<td>A great deal</td>
<td>10 (29.4%)</td>
<td>5 (38.5%)</td>
<td>9 (33.3%)</td>
</tr>
<tr>
<td>2. Makes my study time more efficient</td>
<td>Not at all</td>
<td>2 (5.9%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>A little</td>
<td>6 (17.7%)</td>
<td>0 (0%)</td>
<td>1 (3.7%)</td>
</tr>
<tr>
<td></td>
<td>Somewhat</td>
<td>13 (38.2%)</td>
<td>3 (23.1%)</td>
<td>9 (33.3%)</td>
</tr>
<tr>
<td></td>
<td>Quite a bit</td>
<td>10 (29.4%)</td>
<td>5 (38.5%)</td>
<td>10 (37%)</td>
</tr>
<tr>
<td></td>
<td>A great deal</td>
<td>3 (8.8%)</td>
<td>5 (38.5%)</td>
<td>7 (25.9%)</td>
</tr>
<tr>
<td>3. Increases my engagement with course content</td>
<td>Not at all</td>
<td>3 (8.8%)</td>
<td>1 (7.7%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>A little</td>
<td>3 (8.8%)</td>
<td>0 (0%)</td>
<td>2 (7.4%)</td>
</tr>
<tr>
<td></td>
<td>Somewhat</td>
<td>18 (52.9%)</td>
<td>2 (15.4%)</td>
<td>8 (29.6%)</td>
</tr>
<tr>
<td></td>
<td>Quite a bit</td>
<td>7 (20.6%)</td>
<td>8 (61.5%)</td>
<td>11 (40.7%)</td>
</tr>
<tr>
<td></td>
<td>A great deal</td>
<td>3 (8.8%)</td>
<td>2 (15.4%)</td>
<td>6 (22.2%)</td>
</tr>
</tbody>
</table>

### Table 3: How useful are the following specific resources on MATLAB Marina when studying?

<table>
<thead>
<tr>
<th>Questions</th>
<th>Responses</th>
<th>Fall 2013 (initial) # of responses (% of N=34)</th>
<th>Fall 2013 (end of semester) # of responses (% of N=13)</th>
<th>Past Students # of responses (% of N=27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Primers</td>
<td>Not at all</td>
<td>1 (2.9%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>A little</td>
<td>4 (11.8%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>Somewhat</td>
<td>9 (26.5%)</td>
<td>1 (8.3%)</td>
<td>7 (25.9%)</td>
</tr>
</tbody>
</table>
Table 2: Summary of results from the surveys completed in Fall 2013.

Regarding the use of the VLE in lieu of a textbook, students are using the MATLAB Marina primers and exercises similar to how they would use a traditional textbook with 58.8% (53.9% end of semester) preferring to print out and read hard copies of the primers and exercises versus 32.4% (22.1% end of semester) preferring to download and read electronic copies. Students do not appear to be spending more time reading assigned material on MATLAB Marina than from a traditional textbook (32.4% agree they read more, 32.4% disagree they read more, and 35.3% neutral in the initial survey and 8.3% agree they read more, 58.4% disagree they read more, and 33.3% neutral in end of semester survey). With MATLAB Marina in its current form with primers and exercises, 26.4% of current students and 28.6% of past students indicated they would also prefer a textbook. More than half of current and past students in ENGR1371 did not obtain a required textbook for a course and 10.7% of past students did not buy the required MATLAB textbook [10].

In addition, 85.3% of current students indicated that the features, organization and navigation of the MATLAB Marina website are easy to use (14.7% neutral and 0% disagree). While 32.4% of the current students said that they found using MATLAB Marina the first few times was difficult for them, 70.6% of them agreed that using it became part of their learning routine (within 2-3 weeks of the semester). At the end of the semester, 91% of current students indicated that MATLAB Marina was easy to use and using it became part of their learning routine. Only one student never adjusted to using MATLAB Marina instead of a standard textbook.
### Table 3: Summary of results from the surveys pertaining to use of a textbook vs. MATLAB Marina.

The surveys included some written comments from students and some of the more relevant comments are shown in Table 4.

#### Comments from current students:

- ‘I’d rather have a text book due to limited internet access. It is annoying to switch tabs from internet to MATLAB when practicing exercises. I end up printing anyways and a text would be easier to organize the material. Although the video tutorials are super helpful!’
- ‘I think MATLAB Marina is great! Especially since textbooks are so expensive. It makes college that much more affordable for those of us no a tight budget.’
'Create a text from primers/exercises and sell for $10-15, etc.'
'MATLAB Marina is the best resource for a MATLAB student.'
'Even having the option to purchase MATLAB Marina printed out would be awesome. The information is helpful; it's just easier to use a hard copy.'
'Although I don't feel a textbook should be assigned, I do feel that it should be optional for students that prefer to have one. Also, the primers should explain the figures in greater detail for better understanding.'

Comments from past students:

'Perhaps separate tutorials, one for the concepts, and one to show how to code that concept would be helpful. Practice exercises also would be helpful.'
'The gradually progressive approach would be much more effective. When I learned Matlab, it was hard to keep up with the professor as he coded on the projector. The textbook was very hard to follow and learn with. The video tutorials, which were available after I took the course, would have been much more effective.'
'The MATLAB Marina is an extremely helpful tool that was somewhat helpful during my time in MATLAB but is new and improved!'
'While the new and improved Matlab Marina looks quite useful, I would certainly still purchase a book.'

Table 4: Written comments from the surveys completed in Fall 2013.

Usage Statistics

Google Analytics and YouTube Analytics are currently being used to track website traffic and tutorial usage. The website for the VLE has been used extensively through Fall 2013 with a total of 4,072 visits with 6.43 pages/visit and an average bounce rate of 19.28% (within the state of Georgia). There are a total of 96 tutorials housed on YouTube (matlabmarina channel) which have had a total of 2,299 views (within the state of Georgia) over the last semester, a total of 123,534 views globally over the lifetime of the channel, with 45,112 of them being in the United States.

Discussion

Though these results present preliminary data, several observations can be made from them. First, students are using the MATLAB Marina primers and exercises similar to a standard textbook with about two thirds of students preferring hard copies and one third preferring electronic copies of the materials. A large majority of students used the primers, 82.4% of students in the initial survey and 91.7% in the end of semester survey read at least 60% of them. Fewer students, although still a majority in both the initial and end of semester surveys, used the tutorials even though around 90% of students in both the initial and end of semester surveys indicated they found them useful.

Second, students are using a smaller percentage of the MATLAB Marina materials than needed to master the material in a rigorous introductory programming course. Only 50% of current students in the initial survey indicated they read 80% or more of the primers, 82.4% read at least 60% of the primers, but 17.6% read less than 50% of the primers. In the end of semester survey, only 25% of students indicated they read 80% or more of the primers although 91.7% read 60% or more of the primers. The use of the exercises from the initial survey was a little more encouraging as 29.4% of current students indicated they attempted 80% or more of the exercises, 67.6% attempted 60% or more of the exercises, and 85.3% attempted 40% or more of the exercises. The exercises were not graded so this use is better than expected. However, student use of the exercises decreased by the time of the end of the semester survey with only 8.3% indicating they attempted 80% or more of the exercises, 25.0% attempted 60% or more of the exercises, and 66.7% attempted 40% or more of the exercises. In many cases, even though students see a particular MATLAB Marina component as useful, they are not taking advantage of it. If students are not properly preparing for class they will have trouble completing in class individual and group programming exercises and a flipped classroom is much less effective [9]. A mechanism to encourage more use of the MATLAB Marina resources is needed so students become more self-directed learners and are prepared to actively learn during class. Hence, at this time, the authors do not expect overall success rates in this course to improve significantly unless a higher percentage of students were taking advantage of the provided learning resources and better preparing themselves to learn both inside and outside of class time.
The decline in use of primers, tutorials, and exercises in the end of semester survey responses was consistent with the usage trends from Google Analytics. Discussion with students shed some light on this trend - as the workload, projects, and exams in other classes increased, the amount of time being spent reading the primers, watching the video tutorials, and attempting the exercises decreased. In addition, as the course material progressed into the applications of the fundamental and advanced programming concepts, students began to assume that they did not need to spend as much time practicing coding as in the beginning of the semester.

Thirdly, even with MATLAB Marina in its current form including primers and exercises along with tutorials, over a quarter of current (in the initial survey) and past students indicate they still would like a textbook. This was somewhat surprising as past students of the second author indicated to him that they rarely read their required textbook in other classes and only read instructor posted supplemental notes. The authors had discussed providing a book form of the primers to current students but initially decided against this as the authors assumed students would save or print the primers they wished to view offline. From survey responses and comments, a proportion of students desire a textbook or at least a hard copy of the primers and exercises on MATLAB Marina. In response to this, the authors have made available three hard copies of all primers and exercises for student use in the Engineering Tutoring Center at Armstrong. In future semesters it has also been proposed to create a single downloadable file with all primers and exercises that students can access and create hard or soft copies for their use as needed.

It is interesting to note that the percentage of students indicating they wanted a textbook declined to almost zero in the end of semester survey. Students who may have had problems using MATLAB Marina or adjusting to an online resource versus standard textbook may have withdrawn before the final survey or students may have adjusted to using the online resource and become used to either printing or downloading the needed resources. So while students at the end of the semester did not see the need for a standard textbook if MATLAB Marina was available to them, students at the beginning of the semester preferred hard copies of the course materials.

Lastly, students are more likely to purchase required/suggested software used in the course if an alternative to an expensive textbook is provided. The percentage of past students who purchased the student version of MATLAB was 64.2% and 77.8% indicated they would have bought the software if MATLAB Marina was available to them in its current form. It was pointed out by a past student that some students obtain copies of the MATLAB software without purchasing it so more students probably have access to the MATLAB software than the survey results indicate. The percentage of past students who obtained the required textbook was 89.2% and only 29.6% would still have purchased the textbook if MATLAB Marina was available to them in its current form. Having the student version of MATLAB allows students to work on exercises and projects at any time. In addition, this makes it more conducive for students to use MATLAB in other engineering courses in subsequent semesters. It was also observed that the past students appear to appreciate MATLAB Marina more than current students as it becomes a useful aid for reviewing programming concepts and MATLAB syntax needed for other engineering courses.

In addition, it is observed from preliminary data compiled from sections taught by the same two instructors, that student performance based on final grade distributions and withdrawal percentages, was comparable when using MATLAB Marina in lieu of a textbook (Fall 2013) vs. that in past semesters (Fall 2012, Fall 2011). Similar student performance data will be monitored in future semesters to assess any trends.

CONCLUDING REMARKS AND FUTURE WORK

MATLAB Marina as a VLE provides 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 [19]. Future work will involve the
development of the remaining modules in the VLE and the continual enhancement of the existing modules. In addition, self-assessment tools will also be developed to provide a more effective and complete learning experience. Future assessments including relative student performance will be used to evaluate and assess the impact of this work. The success rates of the course will also be compiled and studied to identify potential improvements.

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REFERENCES
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