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Work-in-Progress: The Impact of MatLab Marina - A Virtual Learning Environment on Student Learning in a Computing for Engineers Course

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Abstract

Programming is a skill that is a crucial component in most engineering analysis and design functions. Hence, all engineering curriculums include programming courses and many use MATLAB, a technical computing language. Teaching and training students to become competent and efficient programmers however, continues to be a challenge. Engineering faculty have implemented several pedagogical approaches to address this challenge, including the use of Virtual Learning Environments (VLEs). This work presents an ongoing, preliminary investigative study of the incorporation of the VLE – MatLab Marina as a supplement in Computing for Engineers courses and its impact on student learning at two institutions: Armstrong Atlantic State University and Georgia Southern University.

Introduction

Current research on the effectiveness of 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 [1-6]. 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, developed by the first author at Armstrong Atlantic State University (Armstrong) is a framework of virtual learning modules dedicated to the improvement of student learning of programming concepts using MATLAB. Currently the VLE consists of ten learning modules with a total of 56 multimedia tutorials. Each learning module consists of a set of multimedia tutorials that present a balanced, dual approach to algorithm development and programming using MATLAB. A pilot study (Fall 2011 and Spring 2012) showed that these tutorials have been used extensively and improve student learning [7]. However, the VLE must be enhanced to include modules covering all programming concepts, and assessment tools and practice exercises to be more effective for student learning and performance. Before such a comprehensive expansion of the VLE is undertaken, it is imperative that a detailed evaluation be performed on its effective implementation.

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. This paper investigates the incorporation of MatLab Marina as supplemental instruction in Computing for Engineers courses. The measured impact of the VLE on student learning, student performance and faculty experience at two institutions: Armstrong and Georgia Southern University (GSU) is evaluated using quantitative and qualitative assessment techniques. The results of this research will highlight effective instructional methodologies for implementing the VLE into this and other programming courses.

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

Course Description: Computing for Engineers

Computing for Engineers (ENGR1371) is a freshmen engineering course wherein students study the fundamentals of programming and learn to solve engineering problems using MATLAB. This course is taught at both institutions as a first-level programming course for all engineering majors. Though the profiles at each institution are different (one a larger regional comprehensive university and the other a smaller public university), the philosophy of student-centered learning and student engagement in the classroom is a cornerstone of engineering instruction at both institutions. When considering the combined student population in this course, currently the average enrollment for the course is 315 students per semester of which about 65% successfully complete the course. Student performance and learning is a clearly a significant problem.

One of the many reasons for this problem is that the combination of traditional introductory programming concepts along with exposure to engineering applications makes for an intensive programming course. The instructors often feel that they need to make a trade-off between covering programming concepts in depth versus covering specific applications that will be used in subsequent engineering courses. 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. It is proposed that MatLab Marina can be used as an effective supplement to help address the challenge of students mastering both programming concepts and specific applications.

Teaching Pedagogy

Currently, ENGR1371 is a three-credit hour semester long traditional, face-to-face course that meets either three times a week for 50 minutes each meeting or twice a week for 75 minutes each meeting at Armstrong. At GSU the same course has a similar teaching pedagogy with a lab component dedicated to programming sessions. For the past few years, the instructors for the course 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 [8]. Students are expected to initially gain exposure to each topic through reading their textbook, posted notes/slides, and other resources. Note that for sections incorporating the VLE, the reading assignments comprise of reviewing the topic to be covered using the corresponding learning module. This pre - instructional strategy has been shown to improve student's cognitive and affective preparedness[9]. These topics are then reinforced in class with short lectures (5 – 10 minutes) followed by class exercises. MATLAB syntax is introduced through the reading and lectures and reinforced with class exercises. Students learn to use MATLAB and develop and debug programs by performing the class exercises along with individual and group programming projects. Outcomes are assessed using completed class exercises and projects along with quizzes and exams. Feedback from class exercises is immediate. Projects are assigned approximately every week and a half and ideally returned within a week. This type of instruction requires students to be prepared for class, hence encouraging student ownership and participation in their learning outcomes (a metacognitive approach [10]). In addition, with the incorporation of MatLab Marina, students can now access at any time, self-paced learning modules based on a modular programming (step-by-step) strategy.

Overview of MatLab Marina

MatLab Marina consists of a main web-site hosted at Armstrong[11] and multimedia tutorials hosted on YouTube. Using YouTube to host the multimedia tutorials ensures that users require only a web browser with a media player. Figure 1 shows the overall proposed organizational structure of the VLE. The VLE will comprise of several learning modules with each module consisting of a primer, a list of frequently used terms, a list of useful commands/functions, sample programs, interactive multimedia tutorials, and assessment tools for the module.

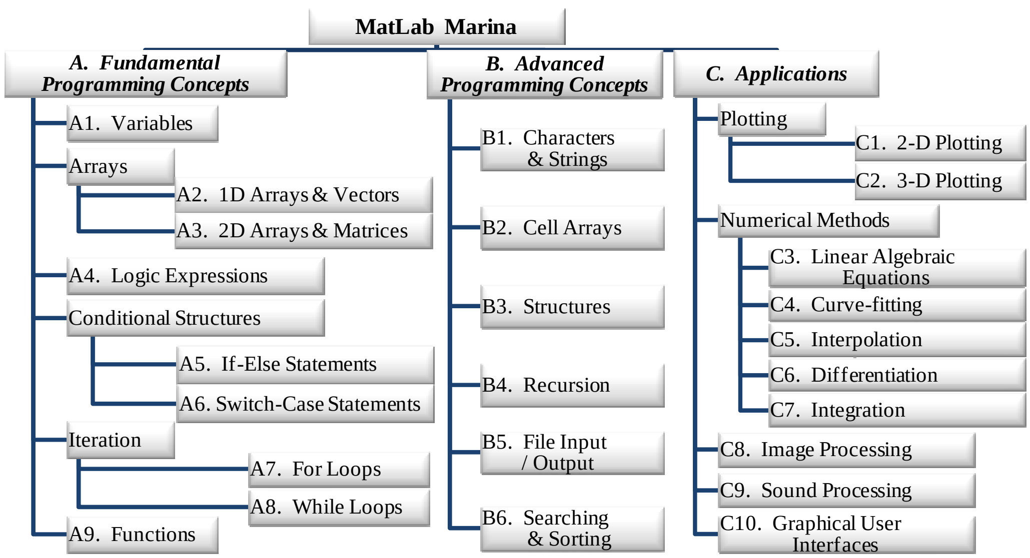

Figure 1 Organizational Structure of MatLab Marina

Currently, the VLE has the preliminary framework of ten modules and a total of 56 multimedia tutorials. These modules cover fundamental programming concepts such as arrays, conditional structures, iteration, functions as well as applications such as plotting and solving linear algebraic equations. However, these modules at present only include multimedia tutorials.

The multimedia tutorials are created using Camtasia Studio [12], a screen recording and video editing software, and Natural Reader [13], a software that converts text to speech using natural voices. While developing these tutorials, special effort is made to ensure that they are 3-5 minutes long, include video with dynamic animations which bring the audience's attention to the step/command under consideration, audio, and captions to quickly and effectively convey knowledge in a multimedia experience. The algorithm illustrating the concept is shown as a flowchart on the right along with the corresponding MATLAB code on the left. The use of dynamic arrows and text boxes (which serve as workspaces that show the variables in process), simultaneously show the step by step working of the algorithm as well as the program. Written captions and a corresponding audio recording of the same provide brief explanations of this step-by-step process. Figure 2 shows snapshots from an example tutorial on 'While Loops' illustrating this process. Though the tutorials do vary in content, the overall approaches are similar. 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 [14]. The tutorials are designed to illustrate the concept in each learning module using relevant engineering or mathematical applications.

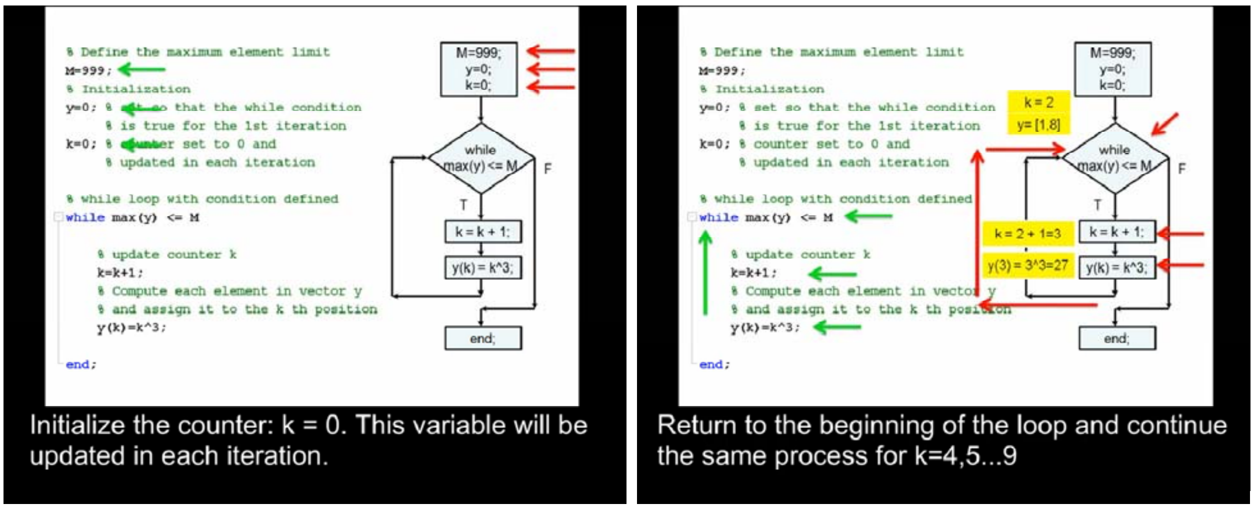

Figure 2 Snapshot of two steps from a multimedia tutorial

Assessment

Assessment techniques included identifying successes and challenges in implementation of MatLab Marina from a faculty perspective, quantitative and qualitative assessment of student learning gains and a comparative control group study. ENGR1371 was offered in several sections at both institutions (Fall 2012): three sections at Armstrong and seven sections at GSU. This allows for a comparative control group study: two sections at GSU (both taught by the same instructor) intentionally incorporated MatLab Marina, one section (taught by the same instructor) does not; the other four sections (taught by other instructors) do not. All three sections at Armstrong incorporate MatLab Marina in the curriculum.

Pre and Post concept tests consisting of five multiple-choice and five fill in the blanks type questions (at least one from each of the modules on fundamental programming concepts) were completed by all students at the beginning and end of the semester respectively. The data from these tests provided: (1) a quantitative assessment of student learning gains and (2) evaluation for a control group study which compared the learning experience and performance of students in sections that intentionally incorporated MatLab Marina vs. those that did not. The pre and post test scores were analyzed using average normalized gains[15] .

Figure 3 shows the average normalized gains for the three sections (labeled as A, B and C) at Armstrong that incorporated MatLab Marina (MM) in the curriculum. It can clearly be observed that the learning gains are significantly higher in the concepts that include an extensive set of tutorials in MatLab Marina. Concepts such as vector evaluation, curvefitting and structures have yet to be developed in the VLE.

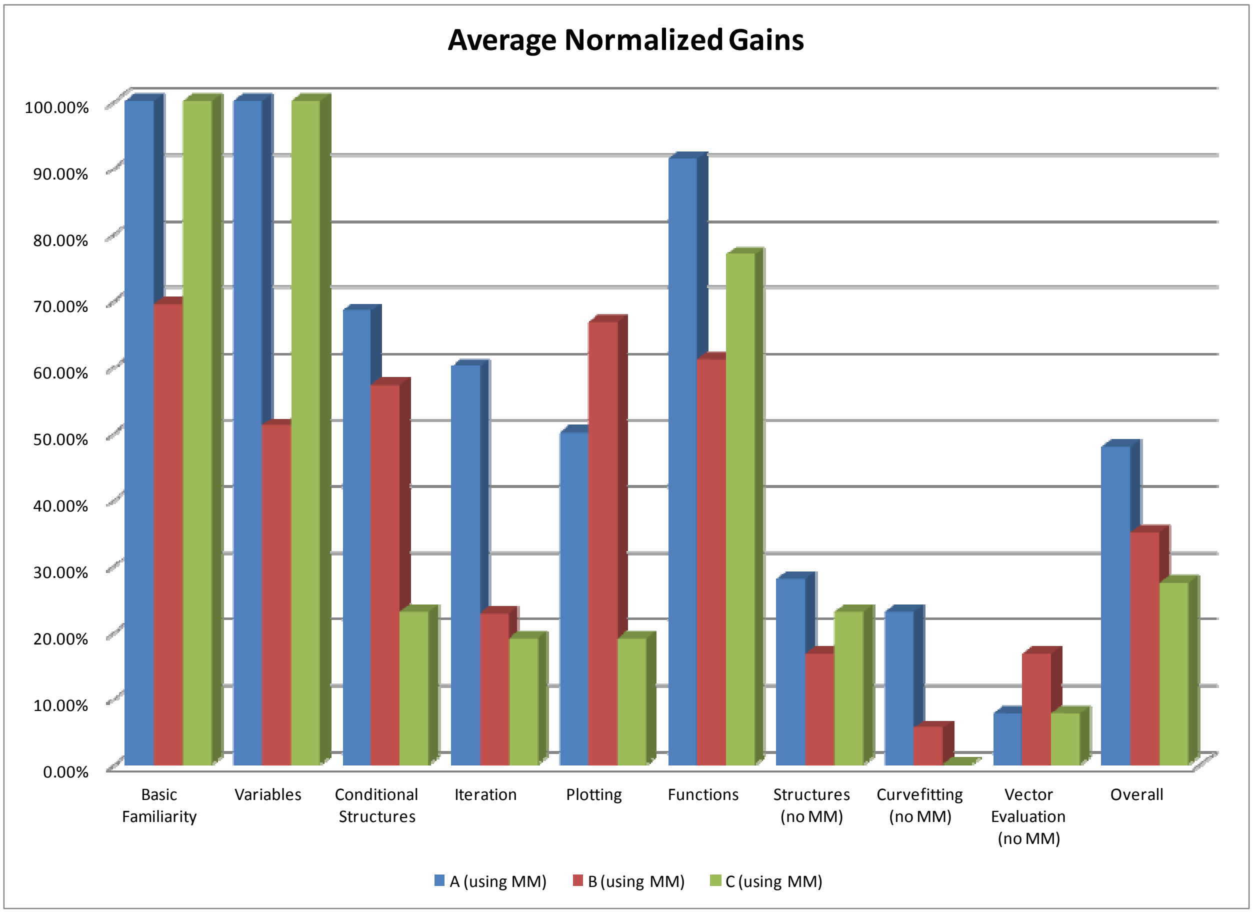

Figure 3: Average Normalized Gains of all three sections at Armstrong (no MM represents topics with no corresponding modules in MatLab Marina).

The average normalized gains of all seven sections at GSU are shown in Figure 4. While it is observed that student performance is lower in the concepts without a corresponding module on MatLab Marina, there is no clear distinction between the overall performances of the sections using the VLE intentionally vs. those that are not. This may be attributed to the discussion of students from one section to the other regarding the availability and use of the VLE and/or the use of other course resources including face-to-face tutoring that may have also contributed to learning gains. Overall, this comparative control group study does show that using MatLab Marina as the pre-instructional resource supplement for the course instead of reading assignments from the textbook and other resources followed by in-class lectures on the same is an equally effective option.

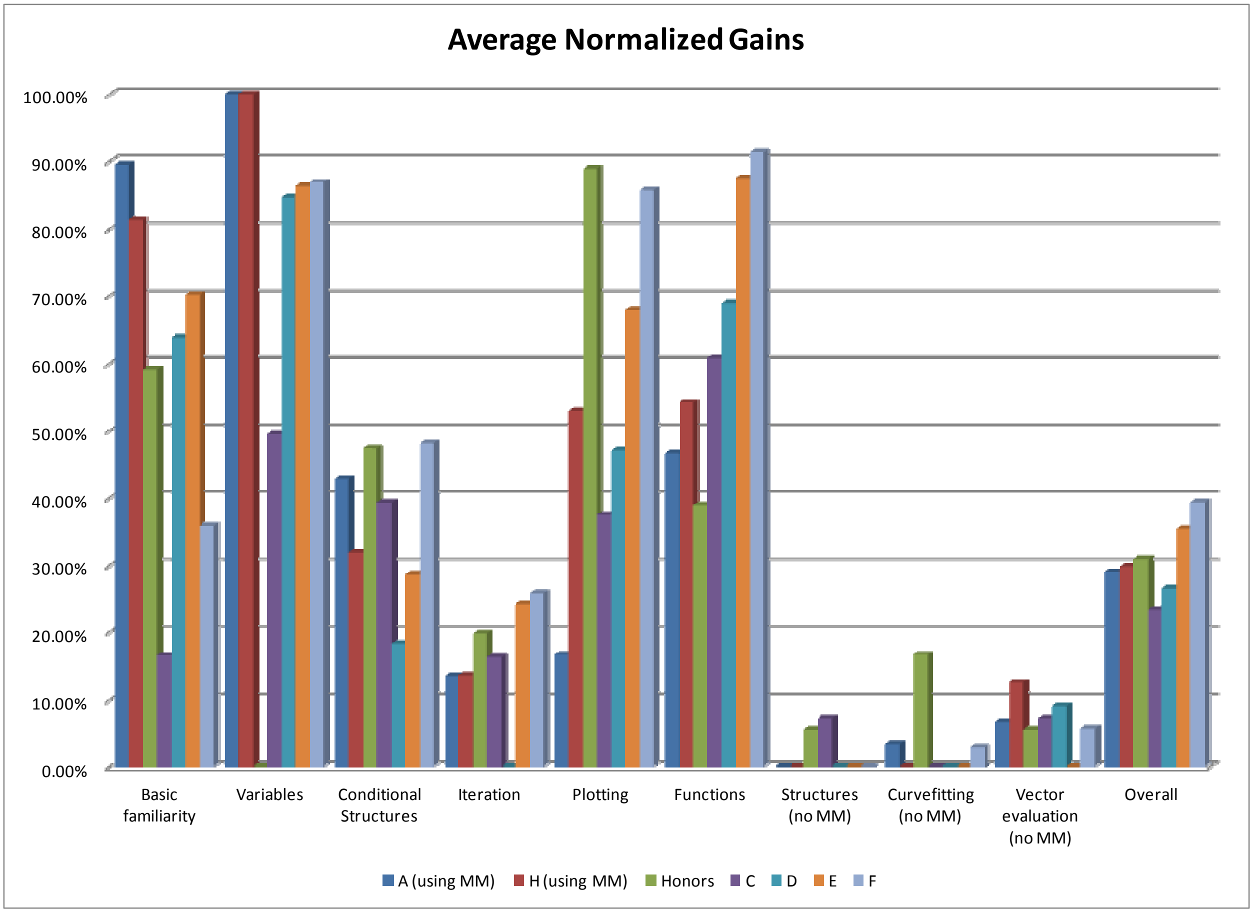

Figure 4: Average Normalized Gains of all seven sections at GSU (no MM represents topics with no corresponding modules on MatLab Marina).

Student Assessment of Learning Gains (SALG) surveys were also used to identify key student experiences and perspectives of the course. All students in the sections that incorporated the VLE completed a baseline survey in the first few weeks of the semester and then a similar, more extensive and detailed survey during the last week of the semester.

The table below (Table 1) shows data from an excerpt of the SALG base survey – questions designed to address the level of comfort and competency students already had with using web-based learning modules, algorithm development and programming. As expected, 90% or more of the students were already competent and comfortable using online resources for learning. A significant number of them considered themselves competent with algorithm development though only 30% had any strong background in other programming languages. Since this is a freshmen programming course, it was assumed that a significant majority of the students were not familiar with programming in MATLAB.

Questions based on current skills:	**Responses**	**Fall 2012**
Presently I can…		
Browse through web-sites to find relevant information (for any topic of interest)	not applicable not at all just a little somewhat a lot a great deal	0 (0%) 0 (0%) 4 (4.88%) 5 (6.10%) 25 (30.49%) 48 (58.54%)
Use virtual (online) learning environments to learn relevant concepts (on any topic of interest)	not applicable not at all just a little somewhat a lot a great deal	1 (1.22%) 1 (1.22%) 7 (8.54%) 14 (17.07%) 24 (29.27%) 35 (42.68%)
Use multimedia tutorials such as those found on YouTube and iTunes U to learn relevant techniques and methodologies (for any topic of interest)	not applicable not at all just a little somewhat a lot a great deal	0 (0%) 0 (0%) 5 (6.10%) 12 (14.63%) 31 (37.80%) 34 (41.46%)
Develop an algorithm (steps to the solution, flowchart, pseudocode, etc) to solve problems.	not applicable not at all just a little somewhat a lot a great deal	1 (1.22%) 3 (3.66%) 7 (8.54%) 38 (46.34%) 22 (26.83%) 11 (13.41%)
Write programs to solve problems (using any language such as JAVA,C,C+, etc. other than MATLAB)	not applicable not at all just a little somewhat a lot a great deal	6 (7.32%) 31 (37.80%) 20 (24.39%) 13 (15.85%) 6 (7.32%) 6 (7.32%)

Table 1: SALG base survey on current skills (Fall 2012, sample size N=82).

Table 2 shows the data from the SALG final survey. The first two questions deal with student's perspective on gains made on their skills with regard to algorithm development and programming using MATLAB. The second two questions address the student's understanding of the application of programming using MATLAB to other courses as well as engineering in general. As shown, about 90% or more of the students feel that they made moderate to great gains in these areas of skills and their understanding.

Questions	**Responses**	**Fall 2012**
As a result of your work in this class, what gains did you make in the following skills?		
Develop an algorithm (steps to the solution, flowchart, pseudocode, etc) to solve problems.	no gains a little gain moderate gain good gain great gain not applicable	2 (3.64%) 3 (5.45%) 16 (29.09%) 21 (38.18%) 12 (21.82%) 1 (1.82%)
Write programs to solve problems using MATLAB	no gains a little gain moderate gain good gain great gain not applicable	1 (1.82%) 2 (3.64%) 11 (20.00%) 17 (30.91%) 24 (43.64%) 0 (0%)
As a result of your work in this class, what gains did you make in your understanding of each of the following?		
How programming using MATLAB relates to concepts I have encountered in other classes	no gains a little gain moderate gain good gain great gain not applicable	2 (3.64%) 3 (5.45%) 14 (25.45%) 24 (43.64%) 12 (21.82%) 0 (0%)
How programming will help solve engineering problems	no gains a little gain moderate gain good gain great gain not applicable	1 (1.82%) 2 (3.64%) 14 (25.45%) 21 (38.18%) 17 (30.91%) 0 (%)

Table 2: SALG survey on certain skills and understanding (Fall 2012, sample size N=55).

Figure 5 shows student perspectives of their learning gains in specific concepts. Similar to the observation based on the pre and post test data, it is seen that students identified no learning gains in a concept such as image and sound processing that is addressed in the course, but has no resource in MatLab Marina. Also observed is the significant gains made in the understanding of functions, which is an important concept used in a procedural programming language such as MATLAB.

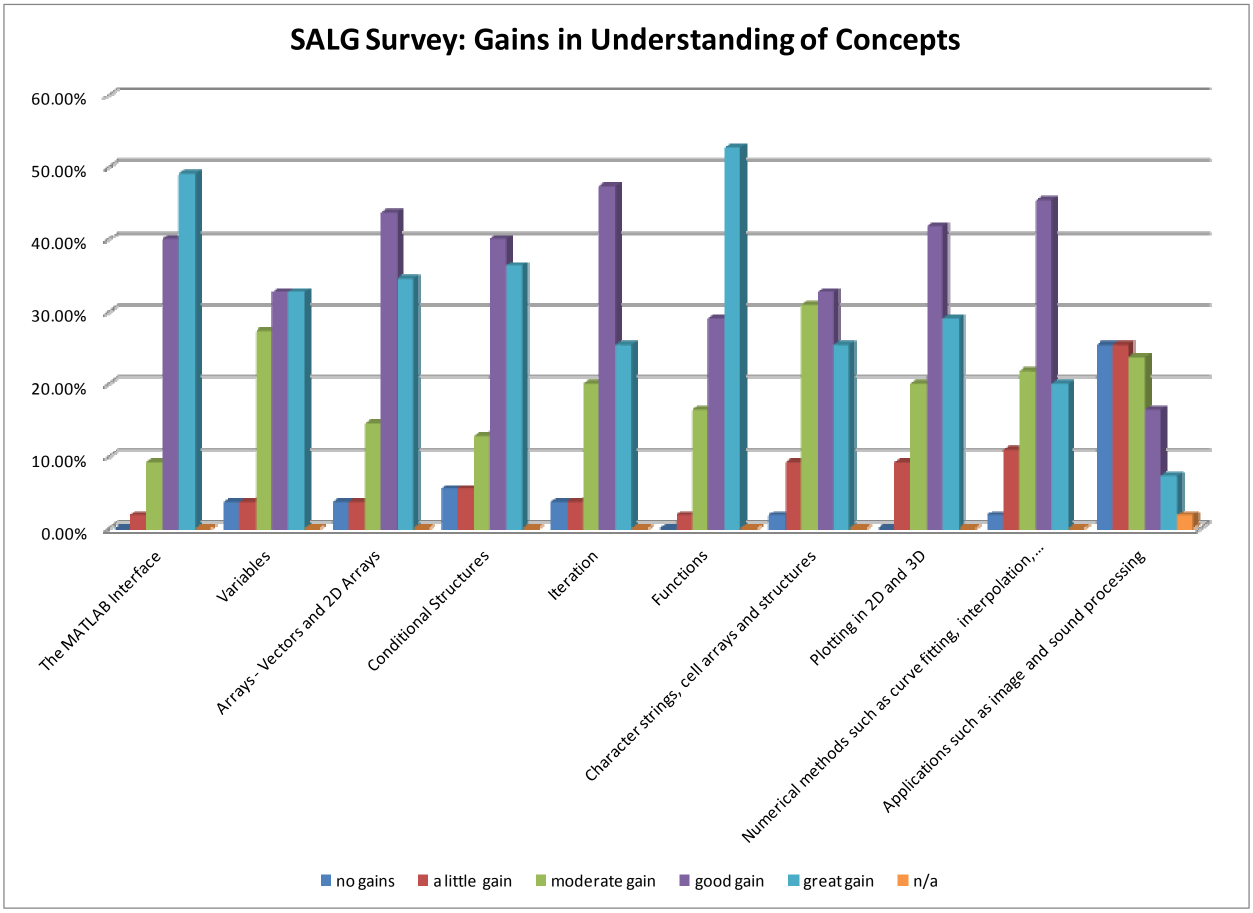

Figure 5: SALG – gains in understanding of concepts (Fall 2012, sample size N=55).

The SALG survey also included questions that addressed student perspective on the efficacy of tools such as immediate feedback on quizzes, support forums (if included in the VLE). The data from Table 3 shows that only 15 of the 55 students consider such feedback good or great help and 20 of them consider support forums/blogs as good or great help.

Questions	Responses	Fall 2012
If feedback on assignments, graded activities and tests is included on MatLab Marina, would it be of...	no help	9 (16.36%)
	little help	12 (21.82%)
	moderate help	14 (25.45%)
	good help	10 (18.18%)
	great help	5 (9.09%)
	not applicable	5 (9.09%)
If support such as user forums, blogs, etc. is included in MatLab Marina, it would be of...	no help	7 (12.73%)
	little help	11 (20.00%)
	moderate help	15 (27.27%)
	good help	12 (21.82%)
	great help	8 (14.55%)
	not applicable	2 (3.64%)

Table 3: SALG survey - student perspectives on tools such as assignment feedback and support forums (Fall 2012, sample size N=55).

In addition, the SALG survey included some written comments from students, a few of which are shown below:
'This class gave me a considerable amount of confidence in MATLAB, yet I'm still vague on some concepts of the application'
'Programming in general is a great way to develop logic.;
'I have gained skills to be able to look at a problem and write a program to come up with the solution. This is true for most cases, but there are still some topics that I do not fully understand.'
'This class made me realize that writing programs is not as hard as it sounds if you learn the concepts one by one.'
'I enjoy matlab a lot more now.'

Discussion

Though MatLab Marina has been in use at Armstrong since Fall 2011 (with only a few modules and tutorials), this was the first attempt to fully incorporate it into the curriculum of ENGR1371 and to introduce its use in another institution GSU. Hence, these results represent preliminary data of a pilot study. This investigative study will be continued this upcoming semester (Spring 2013) as well at both institutions.

Overall, it is observed that the tutorials in the VLE have been used relatively consistently through the Fall 2012 semester (1,262 views in the state of Georgia from the 1st week of class to the week of final exams). Also observed is that the learning modules on certain fundamental programming concepts have been beneficial and effective in student learning.

From a faculty perspective, it is imperative that the VLE be effectively integrated into the curriculum of ENGR1371. The mere existence and availability of such tools does not necessarily render their use by students for learning. Hence, the learning modules must be integrated into the curriculum as pre-instructional reading assignments with a possible quiz/test/assessment tool based on the basic content in the module. This would not only encourage students to take ownership of their learning outcomes, but also allow the instructors more in-class time for hands-on programming sessions.

On another note, an interesting perspective is the apparent extensive use of the tutorials globally (a total of 44,926 views as of 12-27-2012, 3,751 of which are within the state of Georgia and 16,376 within the U.S. as tracked by YouTube Analytics). This work lays the foundation for the effective integration of the VLE into the global engineering community – to be used as a supplement in face-to-face traditional, hybrid and/or fully online programming courses as represented by the current trend in the engineering curriculum [16].

Conclusions and Future Work

This paper presents an overview of MatLab Marina – a Virtual Learning Environment dedicated to the improvement of student learning of programming concepts. MatLab Marina is currently used as a supplement to the course: Computing for Engineers. Overall, the use of the VLE as supplemental instruction has not been detrimental to student performance. Assessment results show that the VLE does improve student's understanding of certain fundamental concepts if used effectively.

Pedagogically, MatLab Marina represents current trends in education where traditional teaching methods are complemented with online learning environments to meet the needs of the next generation. Future work will involve the development of other modules to include in the VLE and the continual enhancement of the existing modules. In addition, primers on concepts and algorithms and self-assessment tools will also be developed to provide a more effective and complete VLE. Future assessments including student surveys and 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. It is proposed herein that MatLab Marina will be a vital supplement to all such courses and will improve student's understanding of concepts, student performance and retention rate. After successful implementation, the VLE will be made available to the global engineering community.

Acknowledgements

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