

Self Learning Laboratory Sessions for Engineering Mathematics

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Abstract: *In this paper, we will discuss the implementation of self learning computer laboratory sessions for a first year mathematics course designed for students from the Faculty of Engineering. Computer laboratory sessions have been part of this course for several years. It typically consists of allocating students into small groups to be taught by instructors. The self learning model significantly reduced the amount of resources required and introduced flexibility and was well received by the students. This was made possible by the availability of free open source software.*

1. Introduction

MA1506 is the course code for a first year mathematics course designed for students from the Faculty of Engineering in the National University of Singapore (NUS). Since 2007, the course syllabus has not been changed and students are taught differential equations and linear algebra over a period of 13 weeks. Together with lectures and tutorials, there is a computer laboratory component where students learn to use MATLAB to visualize solutions of differential equations, solve these equations numerically, as well as compute with matrices. In 2007 and 2008, these sessions were conducted in the traditional manner where the students were allocated into groups of about 30 and taught by a teaching assistant in a physical laboratory so that they could try out the commands in MATLAB as they were being taught. However, the large enrollment of approximately 1300 students for MA1506, resulting in 50 groups meeting three times in a semester, required huge amount of resources in terms of teaching assistants and physical laboratory spaces. Furthermore, it took almost one month to complete one laboratory lesson for all the groups, which resulted in a time lag from when the concept was first taught in lectures till the time when students were solving exercises related to the concepts. This rendered the lessons less effective and was exacerbated by the lack of capable teaching assistants. Interest and attendance of students waned. In 2009, a decision was made to revamp the laboratory sessions with a twofold purpose: to address the lack of interest from students and secondly to address the shortage of space because the number of physical laboratory classrooms was to be halved from four to two in two year's time. It was decided that the laboratory component should be changed from the traditional classroom model to a self learning model. Students were expected to learn to use MATLAB on their own by working on carefully crafted worksheets and submitting an assignment which required them to solve several problems using MATLAB.

2. Implementation

There were two major considerations before we decided on implementing the self learning sessions. Firstly, would student learning suffer from the lack of a physical instructor? Secondly, we were concerned about the ease of access for the students. After deliberation, we concluded that the lack

of a physical instructor would not be a major obstacle to student learning. NUS students are generally technologically savvy. Moreover, the actual new knowledge that they were required to pick up was not substantial. The only new material was the various commands from MATLAB and combining them into short codes of perhaps 10 to 15 lines. This would not be too difficult a task for these students who had previously learnt either C or some other programming language. In fact about a quarter of the students had actually read a module called Introduction to programming in MATLAB. To make the transition smoother for students new to the software, we recorded an introduction video that illustrated some of the commonly used commands, how to plot graphs and also how to combine the various commands into a short script. This was recorded using the Camtasia Studio software, which captures the screen of your computer, and allows you to simultaneously record a soundtrack. One can toggle between a PowerPoint presentation to explain the commands and the actual software screen to demonstrate the various functions of the software. See Figure 2.1 for a screen capture from the video. The second measure taken to help students pick up the skill was rewriting the worksheets to include detailed explanation of the various commands written in a friendly conversational style. An example is given in Figure 2.2. Finally, we recognized that at times, a human instructor is still necessary for answering student queries. This was especially critical when learning new software to help in pointing out the errors in students' command. Hence, we arranged for weekly laboratory clinic sessions where students may walk in with their questions.

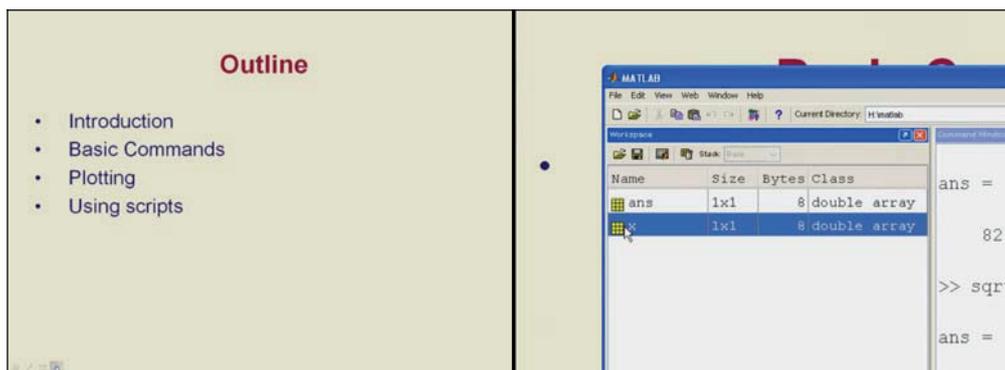


Figure 2.1 Screen capture from the introduction video

The second important concern in implementation was the ease of access. Much as we would like to use MATLAB, since it was the software of choice for engineers, and there was a good chance that our students would have to use it during their final year projects, the software is not free. While NUS has paid for the licenses to use MATLAB in our laboratories, we could not distribute the software to the students. Research into alternative software revealed that Scilab, a free open source software created by INRIA was a suitable alternative. Students could download and install it freely on their own computers and work on the laboratory worksheets at their own convenience, rather than go to a physical class which might be scheduled for some weeks later. Scilab is also very close to MATLAB in terms of both syntax and functionality which is a plus because it would not be difficult for students who had learnt one to switch to the other. See Figure 2.3 for a comparison. In recent years, Scilab has been used increasingly in the teaching of engineering and other related domains. (See [1] to [5].) As mentioned previously, some of the students had read a module on programming using MATLAB and were already familiar with the software. So we produced two sets of teaching material consisting of introduction videos, worksheets, exercises with solutions and

assignments, one written for MATLAB and one written for Scilab. Students were given the flexibility to choose whichever software they preferred. In the end approximately 60% of students who responded to the survey indicated that they used Scilab.

5. Plotting

Suppose we want to plot the following graph, $y = \sin^2(x)$. The most straightforward way is to pick several values of x , $x_1 = 0, x_2 = 1$, etc. Plot the points $(x_i, \sin^2(x_i))$, and join these points. It is clear that this method will only work well when we choose a large number of points which are close together. MATLAB allows us to very efficiently replicate this process. Type the following:

```
>> x = 0: 0.2 : 1 ;
>> y = sin(x).*sin(x);
>> plot(x,y)
```

This does not look like the graph that we want because we used a bad choice of points. Type the following:

```
>> x = 0: 0.01 : 6.28 ;
>> y = sin(x).*sin(x);
>> plot(x,y)
```

This graph looks much better because we used 629 points to plot our graph. Let us dissect these commands line by line.

```
>> x = 0: 0.01 : 6.28 ;
```

We are declaring x as an array (or a row vector) containing the numbers from 0 to 6.28, in increments of 0.01. So x contains 629 values. Notice that the size of x in the Workspace window now says 1×629 . Double click on x to see all the individual values. The semicolon ';' asks MATLAB to execute the command but suppresses the output. Type the same line again, this time without the semicolon and see what happens.

Figure 2.2 Example of worksheet written in conversational style

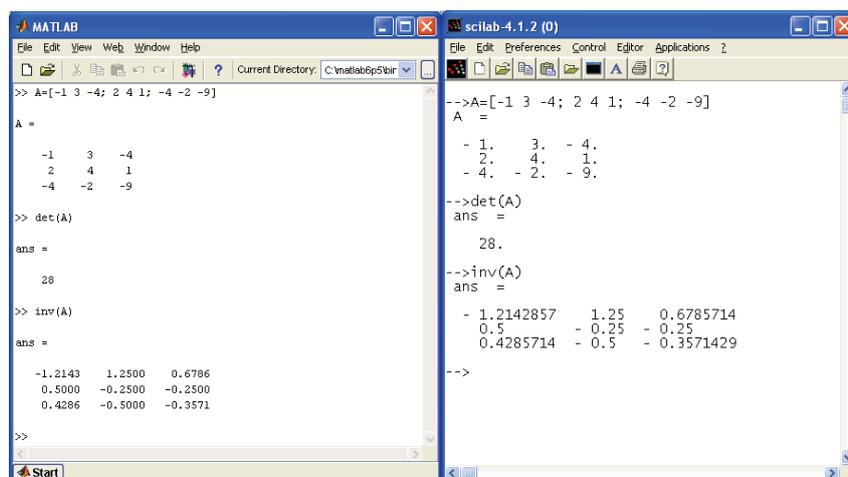


Figure 2.3 Screen shot of MATLAB vs Scilab

In order to ensure students participate and maximize their learning. We required students to submit an assignment which counted towards 5% of their final grade. The assignment tested them on the various skills that they were supposed to pick up in the laboratory sessions. These include 1) plotting solutions of differential equations; 2) graphing of the direction field of differential equations without solving them explicitly; 3) using solvers to numerically approximate the solutions of differential equations that were not easily solvable using analytic methods; 4) computing with matrices, including finding eigenvectors and eigenvalues, and solving systems of linear equations. An example of an assignment question is given in Figure 2.4. The students were given one month to submit their assignments allowing them sufficient learning time to complete their assignments.

Q3) (4 Marks)

Let $N(t)$, measured in kilotons be the total mass of a certain species of shrimp in the Pacific Ocean. We use the logistic model to model the change in shrimp population, with $B = 0.71$ per year and the carrying capacity $N_\infty = 71$ kilotons. Using $t = 0$ to represent 2009, the initial mass $N(0) = 0.3N_\infty$.

(a) If harvesting of 12 kilotons per year is allowed. Plot the direction field of

$$\frac{dN}{dt} = -sN^2 + BN - E.$$

(Hint: You can try to use $0 \leq t, N \leq 80$. Adjust the interval values of t and N until the equilibriums can be seen clearly from your direction field.)

(b) Identify the equilibriums (if any) and their stability and plot the equilibrium lines into your direction field graph.

For this question, you should submit

- i) your answer about the equilibriums,
- ii) a graph of the direction field together with the equilibrium lines in different colours,
- iii) the code you used.

If you are submitting black and white printouts, you may manually draw the equilibrium lines and you will be graded based on the code you submitted.

Figure 2.4 Example of an assignment question

3. Response and Feedback

A survey was conducted after we implemented the model in 2009 and 2011, the first time this self learning model was implemented. In total 1562 students participated in the two surveys and their responses are summarized in Table 3.1 and Table 3.2.

Table 3.1 Student response in 2009

Question		Responses (2009)				
1.	Do you prefer this new mode of self learning lab where you can do the lab on your own time using your own computer, OR do you prefer the traditional mode where there are formal lab classes planned into your timetable?	Self Learning Lab		Formal Lab		
		710 (80.1%)		166 (18.7%)		
2.	Do you find the lab worksheet and assignment relevant to the module?	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		22 (2.5%)	39 (4.4%)	154 (17.4%)	499 (56.3%)	171 (19.3%)
3.	Do you think the tools we learnt in the lab are useful for engineering students?	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		15 (1.7%)	57 (6.4%)	166 (18.7%)	503 (56.8%)	143 (16.1%)

Table 3.2 Student response in 2011

Question		Responses (2011)				
1.	Do you prefer this new mode of self learning lab where you can do the lab on your own time using your own computer, OR do you prefer the traditional mode where there are formal lab classes planned into your timetable?	Self Learning Lab		Formal Lab		
		472 (69.8%)		187 (27.6%)		
2.	Do you find the lab worksheet and assignment relevant to the module?	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		28 (4.1%)	37 (5.4%)	140 (20.7%)	347 (51.3%)	123 (18.1%)
3.	Do you think the tools we learnt in the lab are useful for engineering students?	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		28 (4.1%)	56 (8.2%)	162 (23.9%)	300 (44.3%)	115 (17.0%)

The following are selected feedback collected from the students:

- In my opinion, this MA1506 Lab not only helps me to have some basic knowledge of MATLAB and SciLab but also help me to review some critical problems in the course. The assignment is suitable for every student, I mean, not very difficult and not very easy to complete.
- I feel that the lab assignment is helpful in allowing us to visualise and understand some very abstract topics.
- I found what we learned in the lab are quite relevant and useful to our study.
- I believe that engineering mathematics require more dependence on computers and less on handwritten assignments. Giving more weightage to the lab assignment can bring this message across to engine students.
- I think it's good that we can learn on our own time and when we have questions, we have someone to ask
- I think that the lab assignment is quite useful since it enables us to learn how to use either one of the software and make use of the software for the assignment.

- I think the assignment was useful as it questioned us on a major portion of the syllabus, so those of us who were not up to date with the syllabus had to inevitably cover it in order to do the assignment.
- I think the lab assignment is a good incentive for the students to learn a graphing platform as the platforms like matlab and scilab would be useful in future.
- It is a good part of ma1506, it helps me to get a better understand of ma1506
- Since I am taking IT1005 at the same time, I found that the notes given in MA1506 is indeed more detailed than the one for IT1005 under the same topic. Furthermore, it is very easy to understand and grab the concept by reading the notes. I think it would be better if the lab assignment is more challenging and the percentage of the lab assignment should be higher, like at least 10%.
- The lab assignment is quite useful and relevant to our MA module, especially for our engineering students the methods learned in the labs are quite good!
- I think it was a well designed set of questions given to us to solve. The time given was a bit too much I think but then I think it's fine given the expanse of syllabus the worksheet encompassed.

4. Concluding Remarks

We have described in this paper an attempt to switch from traditional computer laboratory sessions to a self learning model. Besides a major reduction in resources like laboratory space (50% reduction) and manpower usage (40% reduction), we found that 80% of students in 2009 and 70% of students in 2011 preferred the new model. 70% agreed that the laboratory sessions were relevant to the module and more than 60% felt that the tools they learnt were useful for engineering students. A major enabler was the availability of free software like Scilab which could be distributed to the students.

References

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