**Building quantitative skills in Marine Science using MATLAB**

One of the major impediments to teaching undergraduate science majors effectively in a liberal arts institution can be overcoming (many) students’ fears of quantitative analysis, including apprehension related to mathematics and computer programming. This intimidation factor has left many students believing they are not capable to the point that they are not even willing to try to learn these subjects. Alternatively, many modern students have gone through school working towards one “right” answer, and so students in my courses often have a misconception of how science is fundamentally conducted, and the nature of open inquiry. These two points may seem contradictory, but addressing both of these factors is necessary to produce students who are not afraid to ask difficult questions (even ones that may not yield clear solutions), while utilizing a strong logical framework to draw their conclusions. I believe that introducing MATLAB is one way to show students how to more easily use quantitative techniques to make substantial logical deductions from a data set of any size.

**Breaking down misconceptions**

Students who enter the classroom already expecting to fail are in no position to have a positive learning experience. It is important at the start of the semester to set expectations in a realistic way. In my classroom, this includes being clear that we will be quantitative and will make statistical comparisons aided by logical models for behavior of ocean processes, and we will learn new software (i.e. MATLAB) to help meet those goals, while also noting that support will be provided along the way and we will work our way gradually towards bigger problems.

Learning a new programming language (or a program like MATLAB) takes time, and can have a very steep learning curve for students. One approach that can help with this transition is to start with more directed exercises, where students follow step-by-step instructions to produce (primarily) numeric results. This provides a strong, instantaneous feedback for the students, where the early problems have more verifiable outcomes and so the exercise is more about learning the tool than learning concepts. All exercises still tie in to marine themes, and help set the stage for more complex work. Students start with functions they will re-use, and are sometimes given a smaller piece of a larger task to fill in. This technique was one I learned as an undergraduate major in Computer Science at Williams College, where we programmed smaller pieces of Java programs to produce simple computer games. The full program was beyond our skill level, but the framework let us practice smaller tasks while still getting a satisfying result. For my students, this may involve hiding for and while loops initially in functions I provide, then having students attempt to write similar code on their own later in the semester when they are more comfortable with the program.

Finding a balance can be challenging, particularly given that I am often teaching students with a diverse range of backgrounds in math, marine science, and programming, and diverse interests and focuses within the major. It is important not to lose the less advanced students, and so those who are further along are encouraged to help their classmates, ideally keeping everyone engaged even when the level of the assignments might be relatively simple for the more advanced students.

**Progressing through uncertainty**

After providing students with a toolbox of functions and commands, and showing them how to work through steps of validating and visualizing data sets, the next key step is to help them use those skills on their own projects. Students in my upper level elective course, Hydrographic Techniques, conduct two field-based projects where they collect coastal data sets focused on physical parameters and use their new analysis skills to answer a scientific question they have devised. As we move towards these projects, assignments incorporate more essay style questions, to ensure that students are thinking appropriately about the meaning of their analysis results, whether they are numerical, graphical, or some combination of the two.

Students who have been trained to look for the “right” answer are often not comfortable with asking complex questions, even if they have the appropriate background. Once each team in my class has come up with a question or hypothesis that I have approved, the goal is for them to work through the scientific method to best address that hypothesis with their data set, rather than to arrive at some pre-conceived answer. The ability to combine creativity, communication skills, computational analysis and logical thinking can serve students of all majors, and science majors in particular.

I believe a key aspect to finalizing the learning process for a program like MATLAB is to ensure that students use their new skills on an applied problem of interest to them. For some courses, this could be a mini-project based on pre-existing data sets or a theoretical calculation of their choice. In my course, it is the students’ research projects. I have seen that students who skip this step (and use spreadsheet software alone for projects) are often left on the early, steep part of the learning curve for MATLAB and do not see the payoff of the capabilities of replicating analysis, documenting methods, and organizing variables. This realization has been reflected in more recent grading rubrics for projects, which require at least some use of MATLAB to obtain project results. The trial-and-error process, ending in a product that is specific to one group or student, forces more independent learning.

There is a lot that students can gain from learning computational skills in the classroom, integrated with their major coursework and topics of interest. The challenges are diverse, including preconceived notions, varying student knowledge and preparation levels, and student expectations of a typical classroom environment and their (possibly passive) role. In overcoming these challenges, we open students up to a new way of thinking, and a powerful way to look at the world. At a minimum, they can see the potential of these computational tools, and their first course in this area can serve as a stepping stone to further learning and more flexible analytic skills.