

Challenges and successes in teaching online using MATLAB

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Background

I have been teaching image processing, computer vision, machine learning, and (more recently) deep learning using MATLAB since 1996, when I was introduced to (and fell in love with) MATLAB and the Image Processing Toolbox. During the past 25 years, I have used MATLAB in numerous courses taught in different countries, published a couple of textbooks on image processing and related topics using MATLAB, and engaged in numerous MATLAB-related projects, activities, and events.

The technical quality and suitability of MATLAB and its toolboxes for teaching applied computation in multiple fields of science and engineering have been attested by its extensive use and popularity worldwide. Since images are essentially matrices and MATLAB's basic data type is the matrix (or array), using MATLAB has helped teaching students to write cleaner code for matrix manipulations and apply their knowledge of linear algebra to the solution of problems in computer vision, machine learning, and image processing.

In this essay I will focus on two aspects of using MATLAB in my courses:

- (1) How MATLAB's ease of use and gentle learning curve engage the user in an interactive learning style that leads to a mental state known as *flow*.
- (2) How the latest developments in the MATLAB ecosystem have made online teaching and learning easier to faculty and students alike.

MATLAB and Flow

Flow – a concept originally introduced by positive psychologist M. Csikszentmihalyi – can be defined as “the mental state of operation in which the person is fully immersed in what he or she is doing by a feeling of energized focus, full involvement, and success in the process of the activity” [1-2].

I postulate that MATLAB has the potential to be used in a teaching environment in such a way as to enable flow. MATLAB has an intrinsic ability to provide immediate feedback on the student's actions (whether via command-line, scripts, live scripts, or interactive apps), which can be extremely helpful in engaging students, reinforcing their understanding, pointing out their mistakes, and encouraging them to try alternative ways to approach a problem. MATLAB also has the potential to provide students a great sense of control, since they can write their own scripts and functions and control every line of code in their algorithms and applications.

My experience has shown that this intrinsic potential can be maximized by the creation of interactive tutorials¹. These tutorials should leverage MATLAB's excellent features and supplement them with a road map that enables the students to set clear goals and objectives for themselves, with special attention being paid to match the right challenge level with the correct skill level in a staircase-like progression. Many students in my classes have reported experiencing deep concentration and full absorption into the activity, i.e., immersing in a state of *flow*.

¹ One of my textbooks [3] has 37 tutorials for image and video processing that exemplify these pedagogical principles.

These are some of the key principles behind the design of these tutorials:

1. **Clear goals.** The main goal and specific objectives are clearly stated, right at the outset.
2. **Step-by-step procedure.** Students should know where they're going and should follow a meaningful path to get there.
3. **Challenging questions along the way.** The tutorial is interleaved with questions that challenge students to go beyond a (potentially mind-numbing) routine of just following the steps and ask them to perform more elaborate and insightful tasks.
4. **Interactive, almost conversational, style.** The language used in the tutorials is not excessively formal and resembles a conversation between the instructor and the student.

Leveraging the best of MATLAB online

The MATLAB ecosystem has been expanded, in recent years, to accommodate the demands of an online-first world.

Thanks to the campus-wide license agreement between my university and MathWorks, students can download MATLAB and any of its toolboxes to their personal computers as well as to use MATLAB Online, MATLAB Drive, and take online interactive courses.

MATLAB Online allows students the convenience to work directly on a web browser and save their work on their MATLAB Drive. This has the added benefit of reducing the burden on students who might not have the financial conditions to own (and have exclusive access to) a computer with enough computational power and storage space to install and run MATLAB.

I encourage use of these online resources and integrate some of the online learning offerings (particularly the Onramps) into my courses.

Concluding remarks

Over the past 25 years, MATLAB has proven to be an excellent teaching tool to engage students in a deeply immersive interactive learning paradigm. More recently, thanks to numerous online offerings, it has added flexibility and convenience to instructors and students alike.

References

- [1] Csikszentmihalyi, M. (1991), *Flow: The psychology of optimal experience*, Harper Perennial, New York.
- [2] Csikszentmihalyi, M. (1997), 'Flow and Education.', *NAMTA Journal* 22(2), 2--35.
- [3] Marques, O. (2011), *Practical Image and Video Processing Using MATLAB*, Wiley-IEEE Press, New York.