

Animations in an Instrumental Methods Chemistry Class?

Thomas G. Chasteen

Department of Chemistry

Sam Houston State University

Chemistry-Based Animations

Why?

So why would we interrupt our students' lives by requiring them to study a computer-based animation?

Beyond saddling them with the cost of their \$90+ instrumental text book, these poor souls are next required to find a modern computer and run a browser, or a Flash Player, or install QuickTime. A color monitor is required and headphones (in a noisy...I mean quiet student lab) might even be required. What a hassle for students who are already struggling--usually in their senior year--with a looming graduation, the attendant resumes, probable relocation, existential angst, etc. Why indeed.

We all know the reason why these requirements are not so onerous for these young scientists: **Instrumental analysis is a computer course.** While some instrumental chemical signals might still be feed to an analog (paper-based) chart recorder, for instance from a flame ionization detector signal in a gas chromatograph, the chance of this playing an important part in any of our graduates' futures is insignificant. Obviously gone is the time spent teaching chromatographic integration via the cutting and weighing of paper-based peaks, along with teaching our budding chemists the proper way of handing those small, shiny gram weights necessary to operate chain-operated four-place balances. Gone; all gone. No, instrumental methods of analysis are computer-dedicated methods of collecting data and all that involves, almost exclusively using personal computers networked to one instrument and possibly many.

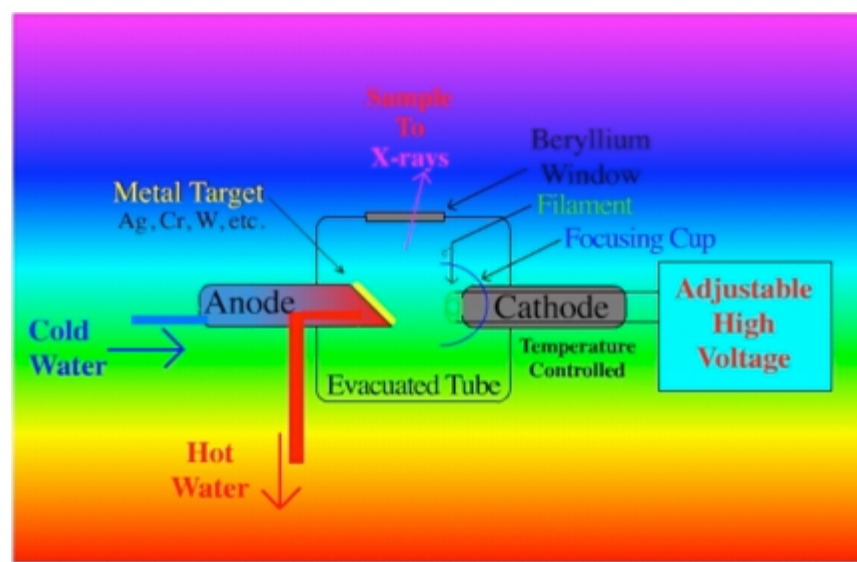


Figure 1. X-ray source in an X-ray spectrometer. Single frame from an animation entitled "X-ray Absorption Spectrometer." Gradient filled background is mercifully not present in the original.

How?

So once we get over the fear of requiring our students to get as involved as possible with modern computers in their chemistry courses, [using computers to help teach specific topics](#) is a natural extension. In my senior-level instrumental analysis course I use animations inside and outside of the course to teach instrumental techniques or particularly important or conceptually difficult points.


The advantages of using a schematic movie of the most difficult instrumental method I teach, gas chromatography/mass spectrometry via a [Macromedia's Shockwave Flash](#) animation will be briefly discussed below. But first I'd like to introduce an older animation constructed using a simple drawing program and [Apple's QuickTime](#). My use of animation vehicles/programs has been morphing as the program options have changed with time. All of the animations I have created to teach with [are listed here](#) in roughly chronological order from the bottom of that page (oldest about 1996) upward in the list to the most recent.

In the "early days" the final file's size was one of the most important variables in each project. The unavailability of broadband ethernet and 56 kb modems that are so prevalent today made the animations files' delivery size **very** important then. As our network connections got faster my projects got larger and larger. As I passed 6 MB in file size (the tilted earth animation for an atmospheric chemistry class in 1999 and then a video taped 15 MB (!) freshman titration in 2000) I realized that except for my students access via our on campus T1 lines (300+ kb/sec), fewer and fewer users would wait for a 6 MB file to download. And this was using all the shrinking tricks: small palette size (fewer pixels), fewer frames per second, and extensive compression using software compressors best suited to the type of images in the animation.

Then came Shockwave Flash. The vector-based nature of this program means that long, complex, full screen animations are possible at a fraction of the size of bitmapped images. And the MP3 sound compression even allows for reasonable sound incorporation in Flash animations, if I could just learn how to synchronize sound with action....

What?

Example 1: The Double Beam Spectrophotometer



The ideas that I focus in on in the "[Double Beam Spectrometer Movie](#)" (a screen shot is in the adjacent Figure) involve, for instance, concepts that are important to the instrument, e.g., double beam "functionality," the separation of reference and sample beams not only in space but in time via the beam splitter. The static textbook drawings though they be many and varied often just haven't been able to get these ideas across to my students.

In the animation the spectrometer's schematic parts are introduced one by one along the light path from source to detector often excluding other instrumental parts for simplicity (look ma, no monochromator). For me this is the main advantage of constructing my own animations: I can build them up frame by frame from the

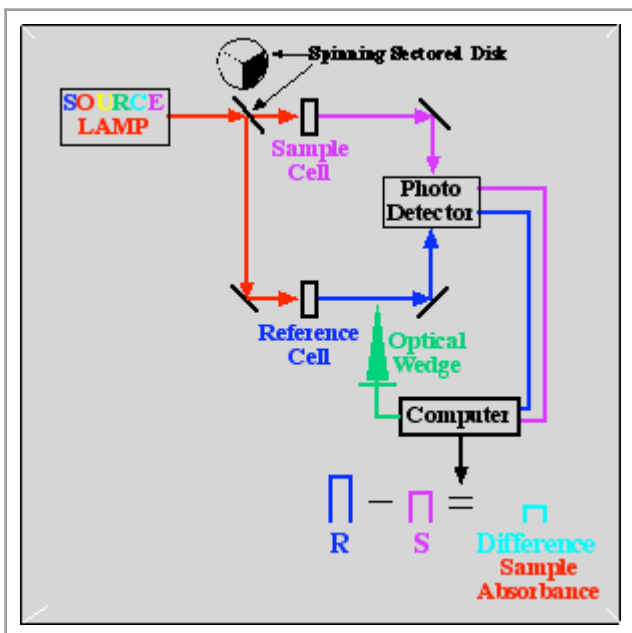


Figure 2. Frame from an animation called "Double Beam Spectrophotometer."

simple ("this represents a mirror", "this is a beam splitter") to the more complex and all the user has to do is move forward and backward in the animation to "disassemble" or "reassemble" the instrument. And I try to "isolate" the parts that cause the most conceptual trouble for my students. Examples of the build-up technique can be found in these animations: [X-ray absorption](#) , [gas chromatography](#) , [GC/MS](#) , [flame](#) and [hydride generation](#) atomic absorption spectrometers for instance. [All the individual animation hyperlinks here and below are to the Flash versions if available. QuickTime or GIF animation versions are available at the link at the top of the page.]

I have also found it difficult to teach some students how the signal is generated by a double beam instrument. The "complete" double beam spectrometer animation provides a moving version of the alternating sample and reference beams with graphical representations of the signal produced by the photomultiplier tube (PMT) as the difference between these signals. [The adjacent image--not actually in the

movie--is false in that respect: both beams never fall simultaneously on the detector in this instrument as displayed]. This is another thing I've decided to incorporate in my instrumental animations: an example of the instrument's signal plotted or in some way represented **as the instrument generates that signal** during the animation. Examples of these adjacent-data-in-the-animation approaches can be found in the [Double Beam Spectrometer](#) , [Tunable Monochromator](#) , [Flame Ionization Detector](#) , [Photoelectric Effect](#) , [GC Cryogenic Focussing](#) , and the following [GC/MS](#) animation.

Example #2: Gas Chromatography/Mass Spectrometry

The most complex instrumental method I teach in my senior instrumental analysis course is gas chromatography/mass spectrometry. There is much involved in this method in hardware instrumentation, data forms/format, data collection/manipulation, and interpretation. And yet it has become so important in modern instrumental laboratories that I feel it is incumbent upon me to give students a very healthy dose of GC/MS while I have frankly let some more traditional techniques slide (thin layer chromatography, for instance). Our GC/MS laboratory component **encompass three weeks**. When one of my best students a few years ago failed to be able to describe in a clear way the differences between a TIC and an MS on a test's essay, I knew I had to do something. This of course suggests that I didn't hold either myself or the student directly responsible, and I didn't; instead it was an intellectual conspiracy of two, along with our textbook!

Originally constructed in Macromedia's Flash format, this animation has a number of programming features I hadn't learned about yet in my earlier animations, and therefore they are simply missing in the earlier animations. In the case of navigational buttons--to allow the user easy movement inside the animation from scene to scene--this simply was not easily

accomplished in my earlier QuickTime animations. The most recent versions of QuickTime allow one to port Flash animations directly into a QuickTime file and keep the navigational buttons and indeed all the Flash features in the QuickTime format.

The adjacent Figure is a snapshot from the most complex scene in the [GC/MS](#) animation (the latter scenes in my animations naturally often show all instrumental parts working together). Yet this image also involves all of the most important features of a GC/MS run: ionized fragments streaming into the mass separator, fragments being detected, the total ion chromatogram (TIC) being generated, and an earlier scan's mass spectrum (MS) being displayed.

When students see this on a PC's monitor they are, frankly, often blown away, not being able to understand what data stems from what process or how the parts integrate. This animation was my response to the confusion I saw on my students' faces.

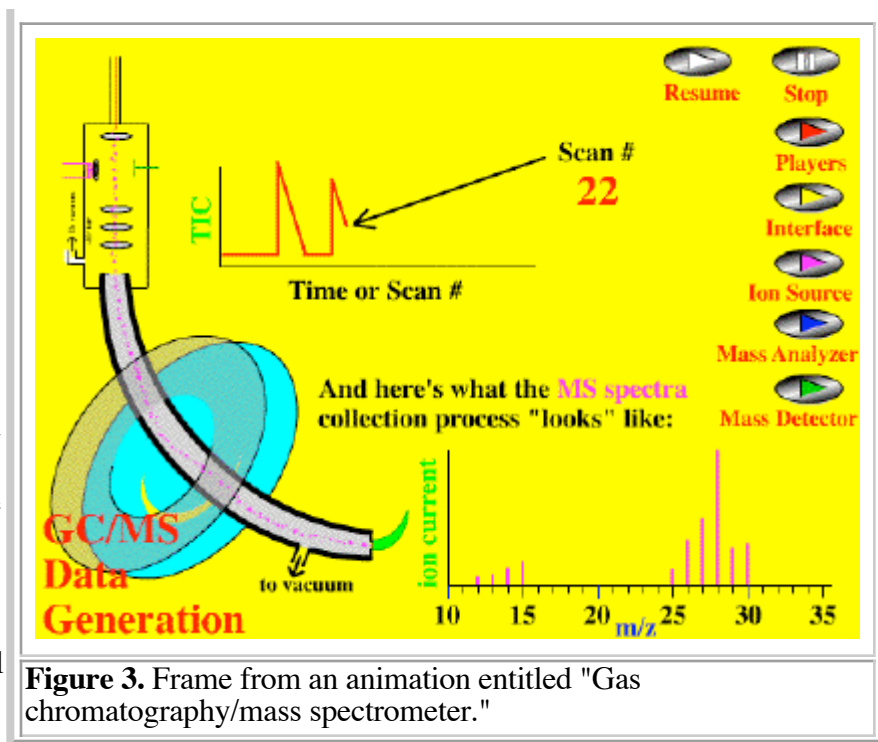


Figure 3. Frame from an animation entitled "Gas chromatography/mass spectrometer."

Obviously as the fundamentals of the instrument are mastered, introduction and study of more complex relationships become possible. For example with GC/MS, space/time in the course previously dedicated to getting the TIC/MS differentiation across can be used to investigate, for instance, more complex fragmentation patterns, formation of metastable peaks, or the benefits of different ionization methods. In atomic absorption spectrometry ([AAS](#)), facile understanding of the fundamental relationships between light absorption and a linear signal generation, frees us, for instance, to study the benefits of hydride generation atomic absorption spectrometry or graphite furnace AAS.

When and Where?

These animations are often introduced in my class using a computer-feed projector. In that venue, lots of starts and stops, forwards and backwards, and judicious pauses of the animation are used to teach the material and as a group we parse out the the functions of all the instrument's parts. If there is sound I almost always turn that off!

Since the files are also [available on the web](#) (and actually getting smaller as time goes on using vector-based programming), the students are also encouraged to investigate the animations out of class. If the situation is appropriate, animations are sometimes used during tests--(often stripped of the instrumental labels)--with essay-based questions about component relationships or functions.

Conclusions

I have finally been able to comfortably approach concepts in a senior level instrumental analysis course using animations, teaching that didn't "go" so well before.

Like most of our efforts to improve our teaching I have as "proof" of this teaching technique's success

only a feeling about my students, a feeling of their more complete understanding of these complex instruments. It's kind of like **the opposite** of what I feel like when one of my better students, on the third test of the semester, completely misunderstands a newly worded complex question. Well if **she** doesn't get it, you can bet the more average student won't and as you grade the rest of the test set that initial hypothesis is born out. Sometimes I just throw out the question altogether.

With these animations, I feel that my testing is more thorough and my intellectual demands more rigorous. Everyone in the class seems to do better with these kinds of tools, the teacher and the students.

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