**Web Resources for Teaching Astronomy with Simulations**

Simulations on the Web (pointers to particularly useful collections and individual simulations)

* PhET– http://phet.colorado.edu Excellent set of simulations covering all of physics and some of astronomy (Discharge Tubes, My Solar System gravity simulator, Greenhouse Effect, etc.) Entire set can be downloaded.
* Astronomy Education at the University of Nebraska – <http://astro.unl.edu> Simulations for student laboratories or feedback during peer instruction. All simulations are indexed and can be downloaded at <http://astro.unl.edu/animationsLinks.html>
* Astronomy and Physics Simulations – <http://hypnagogic.net/sim/> A collection of ~ 15 java simulations. These are older simple simulations, but several are quite useful for demonstrating concepts such as “Fusion in the Sun”, “1 over R squared”, and “Proper Motion”.
* STEM Software – <http://scatter.colorado.edu/STEM-TPSoft/> Set of 10 applets – Drake Equation, Doppler shift, etc.
* Physics Applets – <http://jersey.uoregon.edu/vlab/> A large collection of physics applets with an astronomy section of ~20 applets. The quality and level of documentation varies considerably between simulations. The “Elemental Spectra” applet which illustrates spectra by clicking on an element in the periodic table is very useful.
* Web Simulations – <http://astrosun2.astro.cornell.edu/academics/courses/astro101/herter/java/simulations.htm>

Java simulations on Stellar Parallax, Eclipsing Binary Stars, Spectroscopic Binaries, and Stella Evolution. Useful for getting at the basic concepts, but the graphics and user interfaces are primitive.

* Astronomy Workshop – <http://janus.astro.umd.edu/> A collection of resources for teaching solar system astronomy. The Flash-based Solar System Viewer at <http://janus.astro.umd.edu/SolarSystems/> is particularly useful.
* Down2Earth – <http://down2earth.eu> – Excellent Impact Simulator
* Impact Earth -- <http://www.purdue.edu/impactearth/> -- Another Impact Calculator
* Project Lite Spectrum Explorer – <http://lite.bu.edu/spex/v3/index.html> – A powerful tool for exploring spectra
* The Scale of the Universe 2 -- <http://htwins.net/scale2/> -- “Powers of 10”—like simulator.

Other Large Collections (most are older java)

* <http://www.jgiesen.de/GeoAstro/GeoAstro.htm>
* <http://galileo.phys.virginia.edu/classes/109N/more_stuff/Applets/home.html>
* <http://www.physics.sjsu.edu/tomley/demos.htm>
* <http://www.uni.edu/morgans/ajjar/>
* <http://astro.u-strasbg.fr/~koppen/apindex.html>
* <http://burro.astr.case.edu/JavaLab/> -- largely galaxy related
* <http://www.walter-fendt.de/> -- lots of good physics, some astronomy

Other Simulation-Related Software

* Stellarium – <http://www.stellarium.org> – A particularly visually attractive desktop planetarium that is very useful for teaching basic sky motions. Must be downloaded and installed but runs reliably on a number of platforms.
* Nightshade – <http://www.nightshadesoftware.org/> – A splitoff version of Stellarium more aimed at the planetarium.
* CLEA (Contemporary Laboratory Exercises in Astronomy) -- <http://www3.gettysburg.edu/~marschal/clea/CLEAhome.html> – substantial set of PC-based astronomy laboratories involving simulated astronomical detectors.

References (discussing the effectiveness of teaching with simulations)

* Aldrich, C. (2005). Learning by doing: a comprehensive guide to simulations, computer games, and pedagogy in e-learning and other educational experiences. John Wiley and Sons.
* De Jong, T. Technological Advance s in Inquiry Learning <http://users.edte.utwente.nl/jong/JongScience2006.pdf> This is a shorter version of a 1998 paper “Scientific Discovery Learning with Computer Simulations of Conceptual Domains” downloadable at <http://www.jstor.org/stable/pdfplus/1170753.pdf> that describes the great potential and obstacles involved in teaching with simulations.
* Publications of the PhET group may be found at <http://www.colorado.edu/physics/EducationIssues/research/papers_topic.htm#phet>

including: "PhET: Interactive simulations for teaching and learning physics", "When learning about the real world is better done virtually: A study of substituting computer simulations for laboratory equipment." & “A Study of Educational Simulations Part I - Engagement and Learning”.