Uses of Java Applets in Mathematics Education

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Abstract: This paper illustrates different ways in which Java applets can enhance on-line lessons. We discuss and give instances of the following uses of applets:

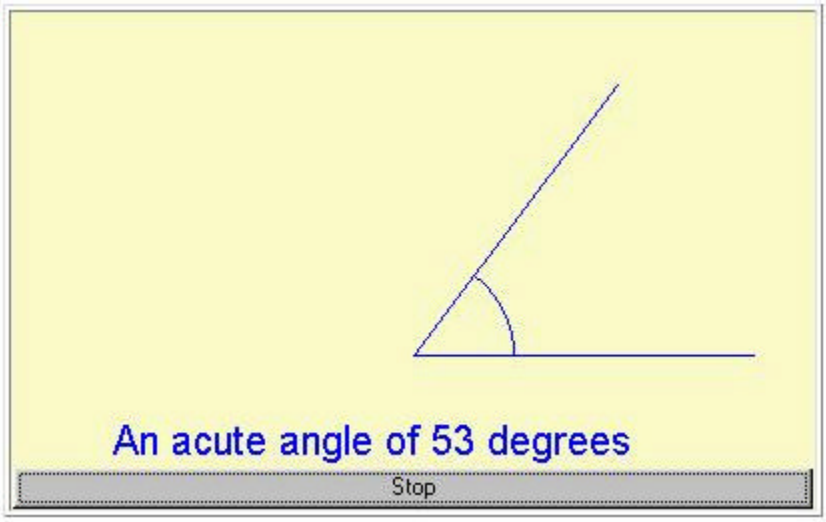
- Applets to generate examples. Instead of a single image with a picture that gives an example of the concept being taught an applet allows us to have very many examples without the need for a lot of space.
- Applets that give students simple exercises to make sure that they have understood a definition or concept.
- Applets that generate data. The students can then analyze the data and try to make reasonable conjectures based on the data.
- Applets that guide a student through a sequence of steps that the student performs while the applet is running.
- Applets that present "picture proofs". With animation it is possible to present picture proofs that one could not do without a computer.
- An applet can also be in the form of a mathematical puzzle. Students are then challenged to explain how the applet works and extract the mathematics from the puzzle.This also helps with developing problem solving skills.
- An applet can set a theme for a whole course. Different versions of an applet can appear at different stages of a course to illustrate aspects of the problem being studied.

Introduction: Java applets began to appear in web pages in 1995. Apart from applets used as decorative pieces on web pages, most "serious" applets are used in business, particularly the financial industry. In the education community we need to explore pedagogical uses to which we can put applets.

This paper aims to demonstrate that applets are very powerful as a medium of instruction. Examples of several ways in which applets can improve mathematics instruction will be given. The reader, however, should not be left with the impression that these applets are all that can be done. The hope is that the reader

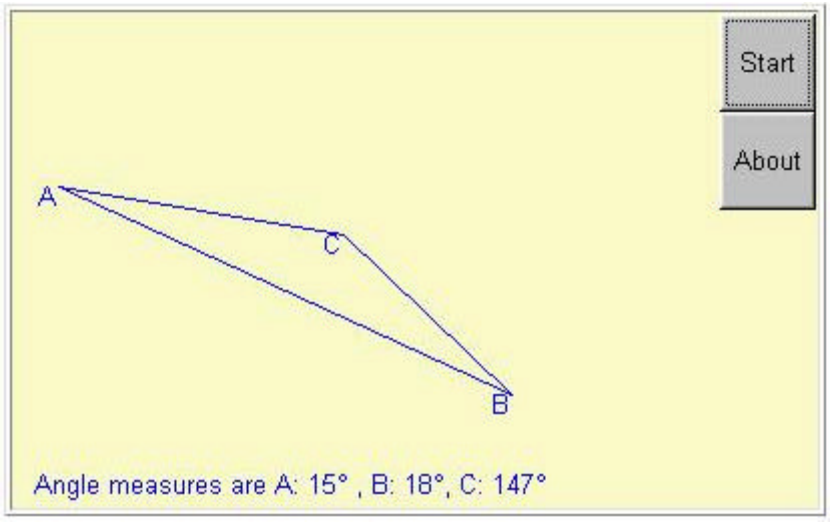
will think of instances where an applet would be appropriate in his or her teaching. The level of the material to be learned can be anywhere from elementary school to tertiary level. Many of the same ideas can also be used in other disciplines of instruction as well.

Applets to generate examples: We start with applets used to generate examples and instances of the objects under discussion. These are applets that replace the standard picture of one instance of an object. The applet below, for example, is inserted in a web page just after acute and obtuse angles have been defined. Rather than one or two pictures of acute and obtuse angles the terminal side sweeps through angles from 0 to 180 degrees.

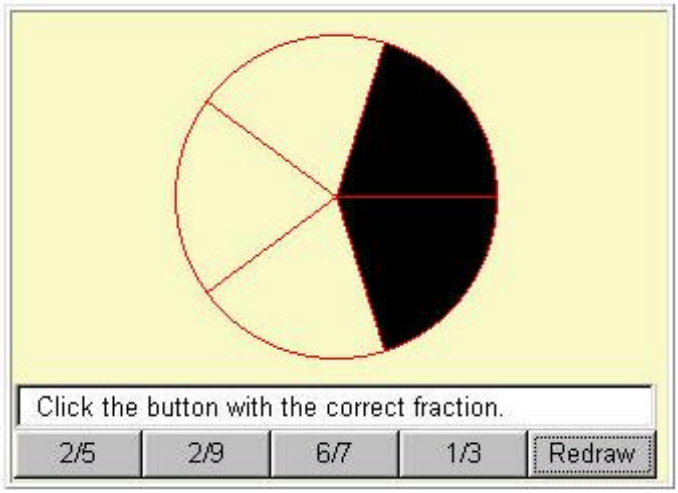


You will find that even people who are quite familiar with acute and obtuse angles will patiently watch the applet as the angles change. What this applet is doing is holding the students attention and reinforcing the definition. Many students watch carefully to see if at 90 degrees it does say right angle. It is desirable to have a start/stop button so that students can stop the animation when they are done with it. That way the applet does not become a distraction.

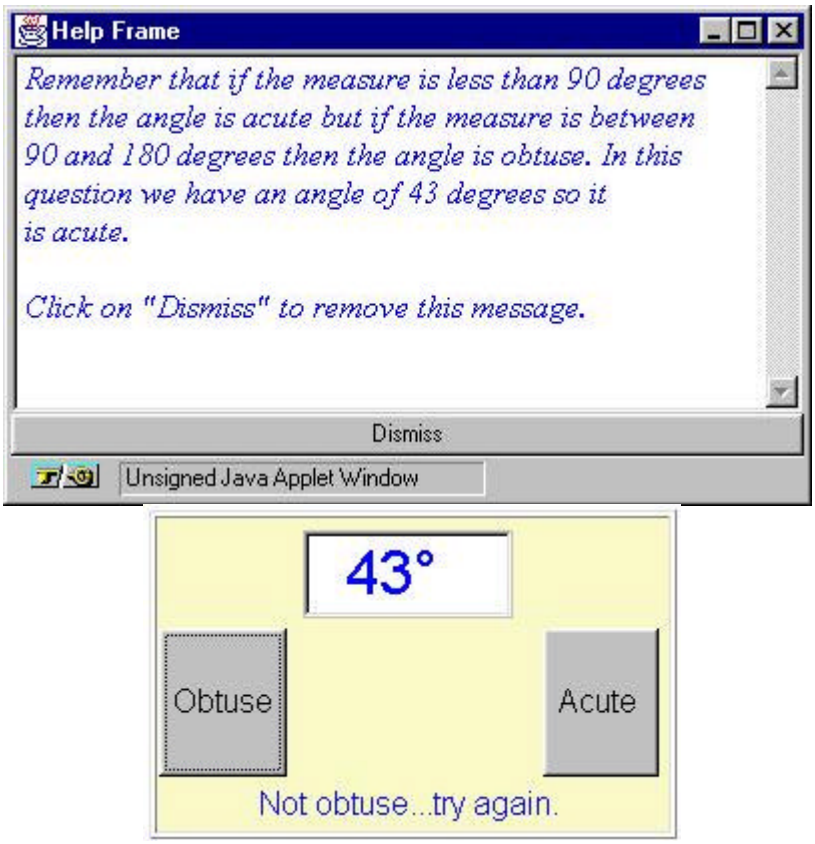
Here is another applet that provides examples, this time of triangles. When the applet runs the sides and angles of the triangle change size as the student watches. We can use this applet to practice estimation. The student can try to stop the applet when one of the angles is a given size, say 45 degrees, without watching the figures.



Applets for simple multiple choice questions: We can use applets to generate simple yes/no or multiple choice questions so that students can get immediate reassurance that they have understood a concept. Since there is a "random" number generator in Java the questions can vary. The applet below can be used by elementary school children, given instructions like "Click on the button with the fraction that represents the part of the pie that is shaded."

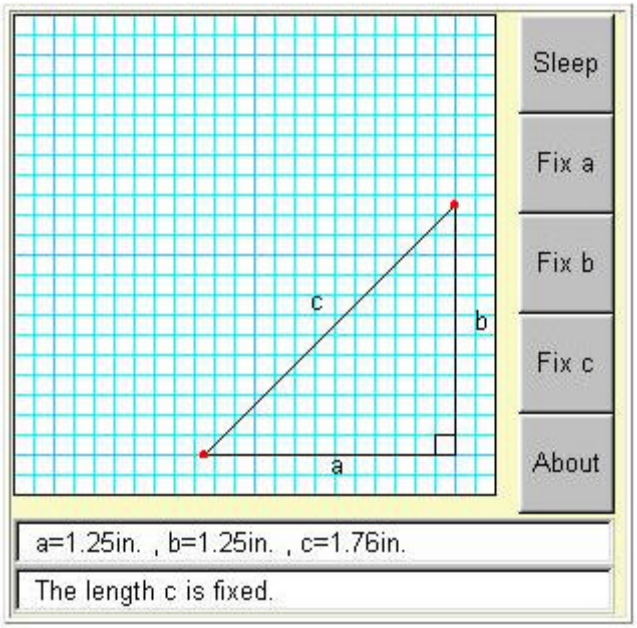


There are many ways to provide feedback using applets. In the applet below the student is supposed to click on the appropriate button when the measure of an angle is displayed in the textbox. An incorrect answer will prompt the applet to put up a frame with a brief explanation as to why the response was incorrect. One can also have the applet take the student to another web page anywhere on the internet where a more detailed explanation can be given. The picture below is of the situation just after an incorrect button is clicked.

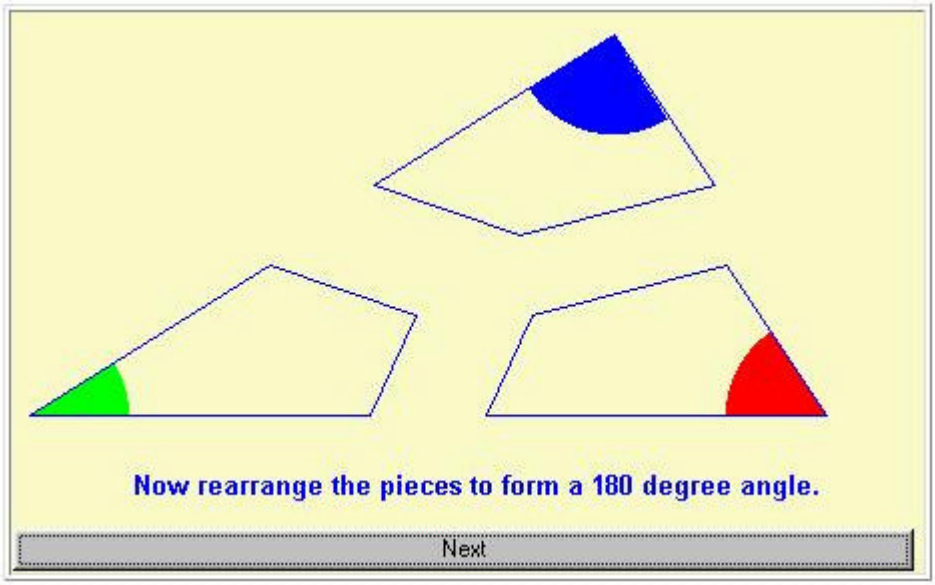


Applets to generate data: Applets can be used as quick ways to generate data for students to analyze. There are times when it is desirable for students to analyze data using graphs and calculators and to make conjectures as to what the explanation for the data is. One could, for instance, have students construct right angled triangles and measure the sides and hopefully after some analyzing come up with a formulation of the Pythagorean Theorem.

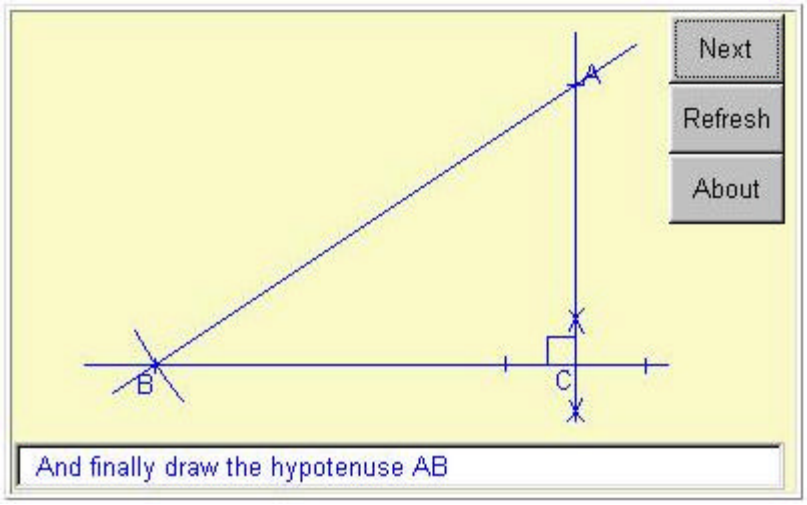
While it is definitely instructive to draw a few right angled triangles it would require a lot of time to draw enough of them to get a table with sufficient data to analyze. We can use an applet to generate data as in the example below. The red dots can be dragged using the mouse and the figures written in a table for analyzing later.



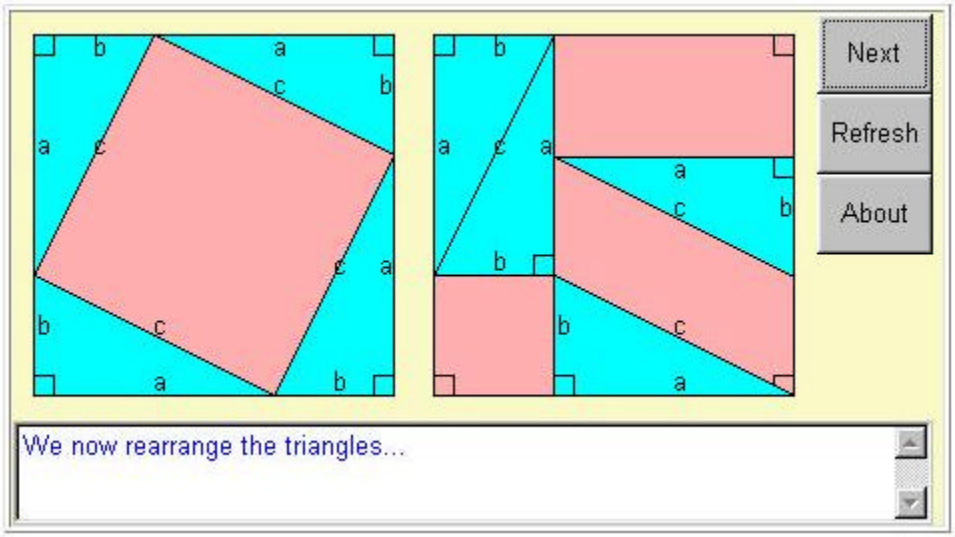
Applets to show a sequence of steps: Applets can guide a student through a sequence of steps with the student performing the activities at each step as the applet runs. The applet below tries to convince the student that the sum of the measures of the angles in a triangle is 180 degrees by having him or her cut up a triangle and rearrange the angles to form a 180 degree angle. The animation makes the experience more memorable than it would be if presented in a textbook. The picture shows one of the phases in the animation.



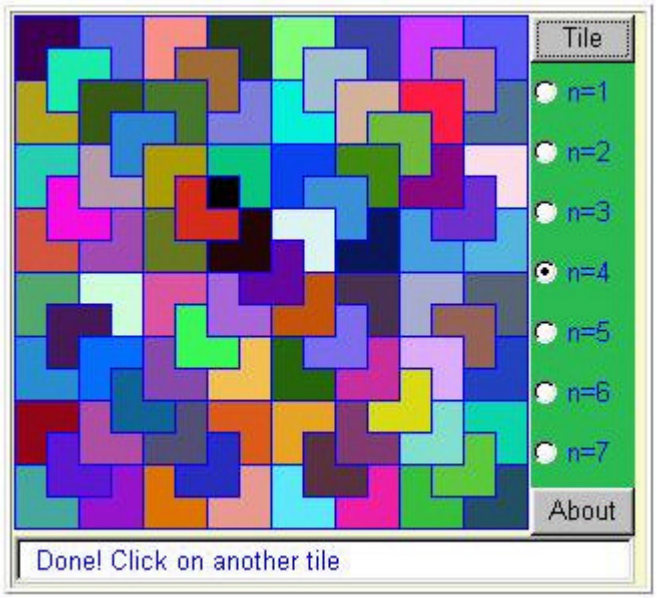
The next applet is one of a sequence of applets for teaching compass and straight edge constructions. At this point the student has already used an applet that teaches how to construct a perpendicular and is learning how to construct a right triangle given the length of one of the legs and that of the hypotenuse.



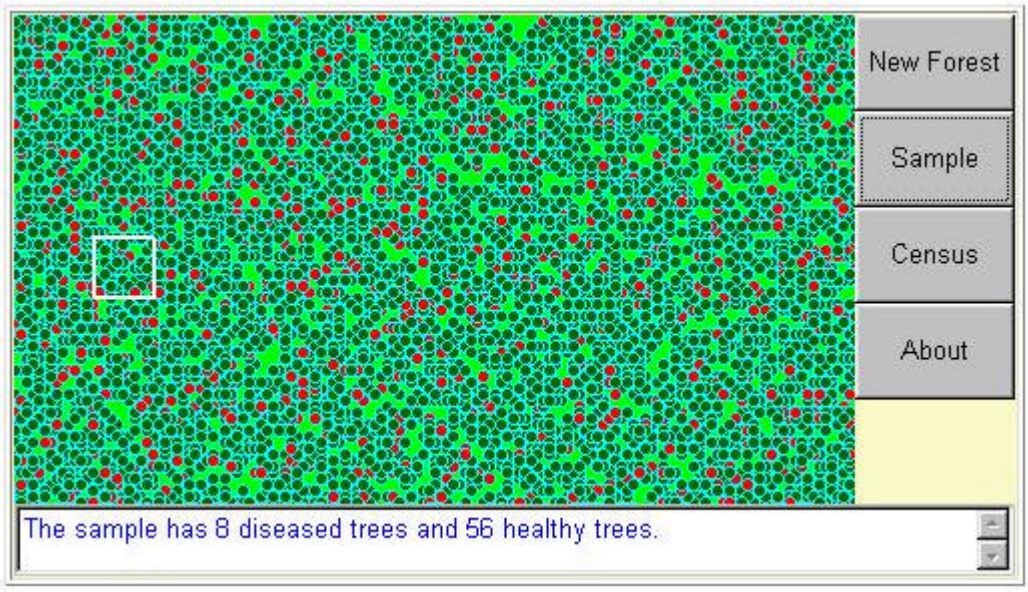
Applets that show animated picture proofs: A popular use of applets is in animated picture proofs. Here is an applet that gives a picture proof of the Pythagorean Theorem. At this point the blue triangles are being moved to new positions.



Applets with mathematical puzzles: An applet can be in the form of a mathematical puzzle. Students are challenged to explain how the applet works. If the level of difficulty of the puzzle is appropriate the students can extract the underlying mathematical concepts. The applet below was written for an undergraduate discrete structures class. It tiles a deficient 2^n by 2^n grid using right trominos. It is a good introduction to the principle of mathematical induction. It also helps students to develop problem solving skills.



Applets that are the center of a course: The final applet I will present is an example of what I call a "theme applet". This is the most ambitious type of project where a whole course revolves around an applet that appears and reappears in different contexts. In this example the applet presents an "overhead photograph" of a forest. Green dots are healthy trees and red ones are diseased trees. The light green patches are grass. The applet is meant for an elementary statistics class. The version of the applet I show takes a sample, gives you the statistics and you (the student) are expected to estimate confidence intervals for the proportion of the trees that are diseased.



One can find many educational applets by using a search engine. The applets referred to in this article can be seen in context at the author's site, Math Cove . There is a large collection of very good applets at the IES Inc. site, Manipula Math

with Java . Other places to look are the Mathematics Section of Gamelan and The Java Repository .
