MIT BLOSSOM Teachers Guide:

In this module, the idea is to put students in a situation similar to the one faced by astronomers when mapping the universe. They need to look for means to make measurements without what we consider the “intuitive” way of doing so. The idea is to show them also that the techniques used are not fancy or complex but based on simple and easily applicable and understandable concepts. If today instruments are complex, the basic ideas are simple.

The main activity is to measure the distance to a tree, or it might be a rock, at a certain distance outside of the classroom. From that simple activity, I aim to make students discover a simple trick to measure a distance using readily available material. They will also discover that a measurement is basically a comparison between a unit and what they would like to measure, knowing that this may not need to be international units. And more importantly, I aim to make them discover that any technique has limitations that depends on the process and the instrument used which ultimately means that you always need a variety of methods to complete and go beyond any one of them.

In order to proceed through the module, the students need to know basic trigonometric functions and how they relate to the angles and sides of a triangle. They will also need to know how to calculate derivatives of these functions, in order to be able to compute an expression for the uncertainties. Ideally, one would be proceeding in a class with a large window to the outside and some clearly available physical object outside, but one may proceed with the module in a completely open or closed space.

Students will have to build with two straws, one cardboard disk, and a pin, a small device to aim and measure angles. You will see a sample of the device in the module. They will need a protactor to label the edge of the disk and measure angles. You should prepare material for one device per pair of students.

The module should not take more than 50 minutes to complete, if the students have the necessary mathematical background I already talked about.

After the first segment, stimulate students to propose ways of measuring a distance without using a stick or a measuring tape. Ultimately one of them may eventually propose a triangle.

In the second part, divide the students in pairs and let them find the equation that allows them to measure the perpendicular to the baseline given the two angles, then build the small device that will allow them to measure angles. It is very important that the measurement with only one device taking the first than the second.

At the third pause, let each pair measure the angle for the two different baselines. Ideally the baseline would make an isosceles triangle with the tree. Let the largest be as close to an equilateral triangle as possible. Each group calculates the distance for each baseline then combine them in front of the class.

After the fourth stop, always in pairs, let them try to find the expression for uncertainty.

The fifth activity is essential. Let them use the same values of the uncertainty they have estimated earlier. For example, 5 degrees for angles and one tile for distance. Then, let them consider, to make things simple, that the two angles are equal. They should know increase or decrease the angles and calculate the distance and its uncertainty until they find that uncertainty is one third of the distance.

Last is a discussion of the motion of the Earth and the fact that you don't need to measure simultaneously the angles. It is important that they discover that we may wait for 6 months to do the second measurement.