

Interactive Processing of Astronomical Observations in a Cooperative Modelling Environment

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Abstract

The astronomy domain provides rich opportunities for learning about natural phenomena. It can involve and motivate a variety of mathematical and physical knowledge and skills. However it is difficult to connect astronomic observations to modelling and calculation tools and to embed them into educational scenarios. It is particularly this challenge which is focused in this paper. Concretely, we build on an existing collaborative modelling framework (Cool Modes) and extend it with specific representations to support learning activities in astronomy. A first field test has been conducted with these extensions.

1. Introduction: Cooperative Modelling

Computing technology for group learning can be more than just an application of computer mediated communication in that it can allow for jointly creating and manipulating “computational objects to think with” in collaborative environments [1]. Our Cool Modes system provides a variety of different modelling languages and comes with a general programming interface for defining and plugging in new languages. Following the metaphor of a flexible paper-like notepad, different modelling languages can be mixed in the same workspace, and they can always be combined with typed or hand-written annotations. This supports a smooth transition between informal and formally structured operational representations.

The prototypical usage scenario for Cool Modes is a classroom setting in which the tool can be used by students working in small groups, e.g. on tablet computers, as well as by the teacher exposing and demonstrating ideas on an interactive whiteboard. Here, the general possibility sharing workspaces flexibly between different participants is not only used to support co-constructive model building but also to enable the flow of information, e.g. in the transition from group work to plenary demonstration and discussion. Here the notion of “educational workflow” or “learning flow” comes into play. It has the following functional facets: (1) allowing for a smooth

transition of intermediate or final results in a group learning setting between different phases and scales of group work; and (2) the consistency and “connectivity” of different software tools (also representation languages) used in the learning process; the inclusion of materials, e.g. from lab phases or field trips.

2. Learning characteristics of the astronomy domain

Astronomy is an exciting and fascinating learning domain, either as part of physics or as subject of its own value. It has a broad range of phenomena and can be subject on different levels through many school years from discovering the moon up to deep sky objects. To understand astronomical theories mathematical (incl. geometrical!) and physical knowledge needs to be integrated. Many schools can already provide access to smaller telescopes for hands on experience and the access to more professional equipment can be provided through the internet (e.g. HoU [3]). In the European project COLDEX [4], astronomy is one domain of scientific experience and learning for which we try to adapt more general software technologies. A good phenomenon to start with astronomical observations is the moon. It can easily be seen and photographed with a digital camera. A small telescope enables to examine different details like craters, walls, mares. Especially the diameters and heights of craters can be measured and calculated already in K8. The mathematical theory of plane geometry and of similar triangles is needed. The students need to process the taken moon images and measure important data out of the resulting image [5].

4. The Cool Modes environment for calculating lunar heights

The scenario in which the students should calculate lunar heights is implemented as a plug-in for Cool Modes. This plug-in provides an object that allows to load images and to measure the necessary distances for

calculating lunar heights. On the left side in figure 1 we see this object in action. One problem we encountered with this method of measuring is that the measured data for very small distances, like the shadow size of the mountain we want to calculate the height of, is relatively imprecise. To improve measurement there is a zooming possibility integrated into the object. Further on we are working with the students in two different working modes. In the first working mode the students try to measure also very small distances with the object explained above. In the second working mode the students use a so-called voting object that allows to have a simple vote among the students. With the help of this object the students can determine the proportion between the shadow that is produced by the crater and the radius of the crater. Afterwards, by knowing the radius of the crater, it is easy to calculate the shadow length. By building the average of all voted shadow lengths the students have determined the length of the crater shadow collaboratively.

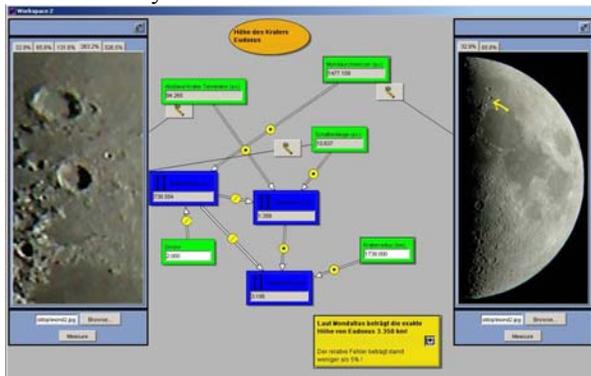


Figure 1 - A crater calculation in Cool Modes

After each measuring of a distance, either if it is done directly by the students using the above mentioned object or if they have determined it collaboratively, an input node for a calculation graph is created and the students can model the needed calculations.

An example model of such a calculation is shown in Figure 1. Within this net, we can see the two parts of the graph that are needed to model the necessary calculations. The one is necessary to model the theorem of intersecting lines and the other is to model the sentence of three that is needed to transfer the measured distances from pixel to kilometers or miles.

5. First scenario usage in school

The described tool has so far been tested in a school lesson (90 minutes, class 9, 12 girls, 12 boys) at a gymnasium. The lesson was structured as follows:

- introduction to the usage of Cool Modes

- group exercise “calculation graphs” (1-3 students per group)
- problem specific introduction: geometrical background of moon crater height calculation
- group exercise: “crater height calculation”

The theoretical introduction needed to develop the relationship between crater height H , crater shadow S , distance L to the terminator and moon radius R was supported by a teacher-built dynamic geometry model which allowed to manipulate the crater height and position interactively on a whiteboard (see figure 2). The students could discover that the two triangles became nearly similar when the crater height was small enough.

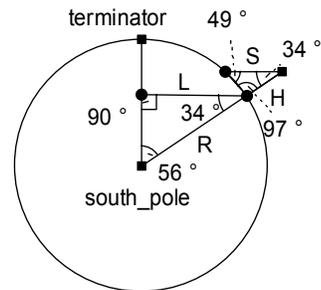


Figure 2 – Dynamic geometry model

Nearly all groups managed to develop a model how to calculate a crater height and use this model to calculate the height of the crater Eudoxus (height: 3350m). Most of the results overestimated the height of Eudoxus within a +20% range. A questionnaire filled in by the students after the lesson confirmed our impression that the tool was considered both usable and useful by the students.

7. References

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