

Starlight in the university lab: Astrolab Practical Activities for Scientific Skills

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1. Introduction

The widespread interest in astronomy can be tapped not only to increase knowledge but also to illuminate the nature of science with the interdisciplinary nature of astronomy and its natural links with technology and instrumentation.

The tutorial Astrolab has been developed in that context. It allows undergraduate students in sciences to plan and to perform real-time observations with a remote telescope, and to transform those observations into a scientific result. It's not a 'recipy' but a learning-by-doing tutorial to acquire research competences and to understand the complexity of practical work through the interdisciplinary nature of astronomy.

Starlight in the university lab (Astrolab) is a project of the Office of Astronomy for Development (OAD, of the International astronomical Union (IAU) ; <http://www.astro4dev.org/>).

2. The role of an astronomy tutorial in the university curriculum for undergraduates.

If a laboratory experience is highly structured the students' attitudes towards the lab learning environment remain overwhelmingly negative. The laboratory experiences are judged by students to be tedious and the relation to the lectures may be not understandable.

In an inquiry-based lab as Astrolab, the students are required to take an active role in determining how to collect and analyze the data to fulfill the goal of the lab. This engages the students more thoroughly in the scientific process but it is also challenging for the tutor. Students lacking experience in this process may require significant coaching and assistance, but on the positive side Astrolab results in:

- developing teamwork abilities,
- understanding the complexity and ambiguity of empirical work,
- developing practical skills,
- enhancing mastery of the subject matter, but not only in astrophysics also in basic physics.

From the economical side, such lab does not require buying or maintaining any equipment.

3. How to collect the data: Virtual Observatory (VO) or direct telescopic observations?

Data to be analyzed during an astronomy lab can be collected in two ways: either from a data base or from observations performed during the lab.

3.1 VO

The Virtual Observatory (VO) is an international astronomical community-based initiative to collect astronomical data (images, spectra, simulations, mission-logs, etc.), to organize them and to develop tools that let astronomers access this huge amount of information. The VO not only amplifies the

work of professional astronomers, it is also a valuable tool for lab activities as this data base can be queried by the students with VO tools developed on purpose.

3.2 Telescopic observations with Remote Telescopes.

Only the most well-resourced universities can afford a permanently mounted telescope as well as the associated equipment in order to create the capability of doing observations in much the same way that research astronomers do, and to obtain reliable data to be analyzed.

They are rare, even in countries with a high GDP. Consequently, remote and robotic telescopes are the perfect tool to be used for hands-on activities.

A remote telescope is permanently accessible, it can be anywhere, allowing observations both from Northern or Southern hemispheres which enlarge the possibility of observable targets.

There are several providers of remote telescopes and their access is through a membership. In the framework of this OAD project, time is granted on the 40cm telescopes of the Las Cumbres Observatory.

No special equipment is required except computing facilities and a fast and stable internet link, but only for a very limited amount of time. This is available nowadays in most of the universities' computing labs.

Lab activities with the VO are fruitful but do not tackle the same objectives.

4. Content of Astrolab: the tutorial

4.1 The concept of the tutorial

Astrolab is based on little fundamental knowledge in astrophysics, the emphasis being made on the hands-on activities, the astronomical targets being selected consequently. Manuals have been developed to give the necessary background in astronomy, and they cover all phases of the tutorial. They can be used by the tutor and by the students.

The student will have to develop an observational research project: she/he has to pose a question that requires to address and to collect the needed data.

Two modules have been tested:

- observations of eclipsing binaries to obtain the light curve, giving access to the radius and mass of the stars
- observations of Cepheids for the period-luminosity relation, giving access to the distances of galaxies.

These modules have been selected as these objects are part of the foundation of the astronomical knowledge and also because of their link with basic physics such as gravitational laws for the eclipsing binaries. The module on eclipsing binary is the one which can be adapted to any curriculum as the back ground in stellar astrophysics needed is few and also it has links with several domains in basic physics.

Following the observations, the analysis of the data will be performed, and then combined with other results, previously obtained either by other groups of students or from the literature, in order to discuss their data.

4.2 What the students have to do

They have to

- select their project
- choose their targets

- prepare an observing schedule (basic, simple)
- obtain some telescope time
- prepare the coordinates and the finding charts
- command the telescope and acquire their own data
- reduce their data
- analyze their data
- interpret their results and transform those observations into a scientific result
- report on their work, in writing or in a presentation

The skills gained by the students cover the domains of understanding the design of an experiment, data interpretation, error analysis, and critical thinking. The execution enhances additional skills such as team work, planning, communication.

4.2.1 Students choose their objects

After the introduction by the tutor, the students search the appropriate object(s) for their project. This can be an eclipsing binary star, or a Cepheid star.

The students will learn to query a data base, the professional one, VizieR, developed at the CDS (Strasbourg Data Center), to select their target, and the interactive sky-atlas Aladin to identify the targets on the images taken.

4.2.2. The students must obtain the necessary telescope time

Once the students' proposal is approved by the tutor, they need to plan their observations. To this end, they draft an observing proposal, showing the distribution of the observing slots in time with a check for the visibility of the source, and the estimated Signal-to-Noise ratio for the exposure time if possible.

The writing of such a proposal is intended to prepare the observations to be done, to describe their context, and to train the student in project writing.

The following points should be developed in the application:

- Title of the proposal
- A concise summary of the proposal: up to about seven lines.
- The telescope time requested and the distribution in time for the study of a variable star
- Technical specificity for the observations: exposure time, the filter(s) to be used.

The necessary information on the visibility of the target are obtained from professional observatories such as the Isaac Newton Group of Telescopes (ING) located on the Canary Islands.

Once the tutor approves the proposal, the students can apply for the first observing slot through the portal site of the remote telescope.

4.2.3. The students command the telescope and acquire their own data

Before launching a telescope time request for many exposures, the use of the selected telescope in real time is advisable in order to check the exposure time, not too short (underexposed images), not too long (saturated images).

4.2.4. Analysing the data

The software for data analysis is IRIS, a free software.

During that stage of the tutorial, numerous questions may be raised by the students connected to the "meaning" of a star image. This gives the opportunity to connect with other fields of studies.

4.2.5. Interpretation of the results and report

The tutor should explain what ‘interpretation’ means, and define ‘expectations’ in function of the competences that are to be acquired by the student through the course and/or the programme. Students can present their results using “power point” presentations or “posters” to other groups allowing for feedback from both peers and tutor. Having to explain and defend their work both in written and oral form helps students better understanding the material. Furthermore, immediate questioning can help students determine which parts of the material remain unclear to them. Students will also be exposed to different analyses when they hear how other groups approached and tackled the problems at hand.

4.2.6. Evaluation and group discussion

Students should receive feedback on the report and the execution of the project during a group discussion. During that discussion the students should also fill in a questionnaire on the project, so that eventual problems and improvements can be noticed.

5. Conclusion

The Astrolab tutorial can be developed at different levels depending on the observing programme. It can also be used for a tutorial limited in time, and it can focus on a more streamlined approach such as the study of the properties of a CCD images, whatever the target is.

This research tutorial Astrolab with a remote telescope uses several concepts that make the project attractive and close to real work research: *ownership* (students choose their objects, plan the project, command the telescope, acquire their own data), a thrilling *pressure* (telescope in another place/continent, the student works in a limited time slot), *chance for failure but also for success* (weather conditions, wrong/good strategy for data acquisition), *community feeling* in developing teamwork abilities.