Education and Heritage in the era of Big Data in Astronomy
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Real data for astronomy class in the college and university

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Abstract. Astronomy education is an efficient means of attracting more people to study science and not just astronomy. The diversity in the majors of the students allows us to expand the knowledge of astronomy to all fields. In this paper, we present our non-traditional method of using real data and observations for our College and University classes, it allows students to learn about the applications and how to use them to study the stars.

Keywords. education, real observations, exoplanets, asteroids

1. Introduction

The correct dissemination of the astronomical material for college students during their classes will help to engage the students in selecting STEM majors. In some cases, the students do not continue with STEM majors but they will be in love with subjects related to space sciences, in which case, they will continue to support astronomy and space sciences through key positions in their careers.

Typical laboratories for College and Universities use Stellarium for the classes. Our idea of use real observations for astronomy class in college and the early years of University born in 2017, when the regular laboratories seem to be boring and not attractive for the students. In this paper we show the details of some of our laboratories to be used by other teachers.

With the public observations and large data sets we decide use one of the catalogs of the Kepler Telescope published by Jason *et al.* (2014) in our course in 2017 and we presented the results in 2018 and were published in Cheung *et al.* (2020). The detailed laboratory is in section 2.

In 2018, we use astronomical observations focus on Asteroids. With the objective to find data to plot our light curve and interpret that, we use the Asteroid Light curve Photometry Database (http://alcdef.org/). The details of this lab are in section 3.

In 2019, we did observation and Analysis using the TMO (60cm) Observatory from NMSU. We observed asteroids during 3 days in remote mode from a classroom, we use different filters such as Blue (B), Visual (V), Red (R), Infrared (I), and H alpha. We obtained a light curve for one asteroid. Also, we use the SDSS for our classes in 2019 and 2020.

Table 1. Parameters of objects associated to exoplanets

KOI	Kepler ID	P (days)	Radius R*	Associated star
41.01	Kepler-100 c	12.815842 (0.000029)	2.25(0.11)	Kepler 100

During Fall 2020, the educative team of Vera Rubin Observatory (LSST), allowed to our students to collaborate with them as testers. So 24 students from the college of the New Mexico State University (DACC-NMSU), and 30 students from El Paso Community College (EPCC Texas), had opportunity to be the first to use a virtual application, as part of their class, and submit their comments to the creators. As instructors we had opportunity to evaluate the application and the impact in the knowledge acquired for the students. Furthermore, we saw how the students were excited when we mentioned that this work will be their contribution to a national astronomical and educative science project.

In section 4, we present a couple of innovative activities: The city in the space, and Searching one habitable planet.

2. Analysis of professional astronomical observations

2.1. *Exoplanets*

One exoplanet is a planet outside of our Solar System. Usually this kind of objects orbit other star, but there are exoplanets that are not related to a star, called rogue planets. In this laboratory we worked with exoplanets associated to one star.

The first confirmed detection was doing by Michel Mayor in 1995 with 51 Pegasi b, it is at 50 ly from Earth.

The Kepler spacecraft launched in March 2009 and spent a little over four years monitoring more than 150,000 stars in the Cygnus-Lyra region. The primary science objective of the Kepler mission was transit-driven exoplanet detection with an emphasis on terrestrial (Radius major than 2.5 Radius Earth) planets located within the habitable zones of Sun-like stars.

The objective of this Laboratory is learn how to analyze scientific information from literature, then create tables and graphics to compare the exoplanets with planets of our Solar System.

For this laboratory we use the published catalog by Jason *et al.* (2014). We can find information for the observation section and planet candidate sample. Also, information from the measuring Planet Parameters for this laboratory. The specific information to do this practice related to the planets is the identifier KOI, Kepler ID , P (period days), Rro (Radius planet), we obtain Teff (effective temperature) and R (Radius star). Also, Mj mass (in Jupiter Radius) and radius Rj (in Jupiter units), PC (planetary candidate), ro (stellar density) can also be used if you wanted a more complete study (pag.5,11,42, 43,57, 58). We create a table using the information from the page 42 of stellar parameters, the table should contain KOI (Kepler Object of Interest), Kepler ID, Temperature (Teff with errors), and R* (with errors). For example, Kepler 100 has associated two exoplanets in this work, Kepler 100-b and Kepler 100-c. Table 1 shows the parameters for Kepler 100-c, the Table 2 shows the parameters of the star associated to Kepler 100-c. Now the students can create a plot period vs radius (planet) using the information of the table 1 and other plot with Teff vs R* using the table 2, with the plots the students can interpret the plots. We selected information for the first twenty systems from the table of the paper for limit of time in class.

Previously we reported results of this lab in Cheung *et al.* (2020) but never the procedure with detail. The students compared the exoplanets systems with our Solar system. Some of the results of this comparison are for example: Kepler 65 is a star more massive

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Table 2. Parameters of the star associated to exoplanet

KOI	Kepler ID	Teff (K)	R*rsun
41	Kepler-100	5825(75)	1.490(0.035)

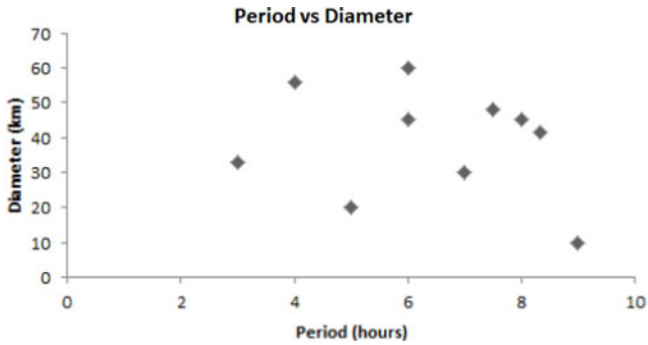

Figure 1. Relation between the Diameter and the Rotation Period for the asteroids laboratory.

than the Sun and has at three planets named (b, c and d). Kepler 65-c, with a radius of 2.57 ER, it is classified as Neptune size. Kepler 65-b with earth radius of 1.53 is a Super-Earth size which is similar to Kepler 65-d.

2.2. *Asteroids*

The objectives are to find a relation between the Diameter and the Rotation Period from the Photometric data. We use the Asteroid Light curve Photometry Database form the webpage http://alcdef.org/.

The students need to follow the instructions as follows: Click in the Search Database, it will go to other page for Asteroid search; In the search box write the name of the asteroid and click in submit. You need do that for all the asteroids of your list; At the bottom you will see a small table with the complete name of the asteroid, select the name of the asteroid and then display; Go to the bottom and find the summary table; Take note in one table of the diameter (km) and the period (hrs) of the asteroids from the bell asteroid zone. Fill other table for the NEAs (Near Earth Asteroids). Create a table in excel in order to plot the information, write the first column the value for Period and in the second column the value for Distance.The Period should be in X axes and Diameter in Y axes. Now the students can interpret the plot (See fig 1).

3. Innovation

3.1. *The city in the space*

The activity consists in write one essay in a multidisciplinary team. They need to explain what would be their contribution to an imaginary city a planet like Tatooine. The students need to assume the next considerations about the city: It is under construction, inside a dome with a diameter of 60 km, and with a supply of water from a region of craters. The settlement lacks pipes to transport water and the essential services. Also, it requires energy that will be obtained with solar panels. The area designated, already has some pre-built houses and one works as a school.

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3.2. *Searching one habitable planet*

The Sun is dying and to get a ticket for a spaceship, students need to propose a close star with possibility of have an Earthlike planet. Students need to review concepts as habitable zones and type of stars for this essay. Students need to review extrasolar planet lists. Take in consideration distances and the interstellar conditions of the trip.This trip will last several generations, so students need to explain how their college skills will be necessary during this long trip.

After review all the project turned by the students, it call the attention that 75 percentage choose as the favorite candidate to escape of the death of the Sun and a possible future planet for humankind Proxima Centauri b. All of them use this option because it is an Earth like planet, close to a red star within the habitable zone. Concepts that they learned during the class. Few of them recognize that this kind of red dwarf present a high risk for the flares and the high levels of possible UV radiation. Some mention mechanisms of "evolution" to adapt a new environment.

Half of the works give a great summary of all the semester in their description. So this exercise help us to recognize how much our students learned during the semester. Also reading the references, they not only use the text book to do this work. The looked for books, magazines, webpages of different space agencies. Even science fiction was integrated in their works but they tried to be critical in what parts they can trust.

4. Conclusion

Our results show 3 educative objectives reached. The first one is an empirical mathematical interpretation: with the exoplanet systems activity, students learn and use Excel to create tables of data, plot a graphic, and practice interpretation of the information. This new skill is used with the next activity and empirically they have found relations between Diameter and Rotation period from Photometric data of asteroids. The second objective was to introduce the principles of research, and try to be critic: in order to look for a habitable planet, students red and look for different sources. They compared information, and surprisingly almost all reached the same conclusion, with some of them still mentioning some uncertainty. Finally, the third looks for the self-motivation to continue with their majors, they highlight their own skills, and we lead them to feel important in their future job, without import where they will be. In their essays they describe themselves as an important part of a crew.

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