STUDENT WORKSHEET

Exploring Exoplanets with Real Data

A 90-minute high-school activity using the exoplanet.eu database

Designed in the framework of Exo4Edu (Erasmus+).
Author : Alain Doressoundiram (Observatoire de Paris - PSL)

What students will do

- Build histograms and scatter plots from a real exoplanet database
- Compare physical trends with observational biases
- Identify exoplanet families using mass, radius and orbital data
- Test Kepler's third law with a real planetary system

Level: ages 15–18 | **Duration: 90 min** | **Pairs or groups of 3**

Lesson focus

Astronomy
Data literacy
Graphs and log scales
Scientific reasoning
Detection methods and bias

Quick access

Database

https://exoplanet.eu/

Project

https://exo4edu.eu/

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Exploring Exoplanets with Real Data

High-school worksheet · 90 minutes · based on the exoplanet.eu database · Exo4Edu framework

ACTIVITY OVERVIEW	
Target level	Upper secondary / high school (ages 15–18)
Duration	90 minutes
Working mode	Pairs or groups of 3
Web tools	Use exoplanet.eu → Plots → Histogram / Scatter
Prior knowledge	Reading graphs, basic logarithms, orbital vocabulary

Context

This activity uses the public exoplanet.eu catalogue and its browser-based plotting tools. It is designed within Exo4Edu, an Erasmus+ project that helps teachers bring authentic exoplanet research into the classroom.

Learning objectives

- Use a real scientific database and navigate interactive plots.
- Interpret histograms and scatter plots using linear and logarithmic scales.
- Distinguish physical trends from observational selection effects.
- Identify major exoplanet families from mass, radius and orbital properties.
- Recognize Kepler's third law in real planetary data.

Part	Main focus	Suggested time
A	Discovery history and the "discovery boom"	15 min
B	Histograms: mass, orbital distance and eccentricity	30 min
C	Mass–radius diagram and planetary families	20 min
D	Period vs semi-major axis: Kepler's law	15 min
Wrap-up	Synthesis and extension	10 min

Important scientific idea The catalogue reflects both astrophysics and detection bias: massive or short-period planets are often easier to detect than small, distant planets.

PART A — The discovery boom

15 min

Goal: understand how the number of known exoplanets changed over time and why it accelerated.

How to build the plot

- Open exoplanet.eu, then go to Plots → Histogram.
- Set the variable to discovery year (or discovered).
- Display the histogram of discoveries per year.
- If needed, zoom or download the figure.

Questions to answer

- During which periods does the number of discoveries increase most strongly?
- Suggest two reasons for these increases. Think about new observing programs or space missions.
- Why does the histogram not rise smoothly from one year to the next?

Part A — short written conclusion

PART B — What kinds of planets are easiest to detect?

30 min

Use the Histogram tool for the three variables below. Complete the observation table as you work.

Variable	Useful settings	Main pattern you observe	Physics / bias / both?
Mass	Try Earth-mass units and a log scale.	....	.....
Semi-major axis	Use a log scale and compare with Mercury, Earth and Jupiter.	....	.....
Eccentricity	Start linear, then compare the overall spread.	....	.....

Log-scale reminder On a logarithmic axis, equal steps correspond to multiplying by the same factor (for example 1 → 10 → 100). This is very useful when planetary properties span several powers of ten.

PART B — Interpreting the histograms

continued

1. Mass histogram: what are the approximate minimum and maximum masses visible in the database? When you switch to Earth-mass units and a log scale, do you notice a change in the distribution around a few tens of Earth masses?
2. Semi-major axis histogram: where are most detected planets located relative to their star? Compare your answer with Mercury (0.39 AU), Earth (1 AU) and Jupiter (5.2 AU).
3. Why are close-in planets often overrepresented in exoplanet surveys?
4. Eccentricity histogram: are nearly circular or highly elongated orbits more common? Compare this with the orbits in our Solar System.

Part B — key interpretation notes

PART C — Mass–radius diagram: what are planets made of?

20 min

Open Plots → Scatter. Plot mass versus radius. Use Earth units on both axes and try a log scale on both axes.

1. Identify at least three broad families of planets or objects in the diagram (for example rocky planets, sub-Neptunes, gas giants).
2. Do planets with Earth-like radius all have the same mass? What does this tell you about density and composition?
3. Where would you expect dense rocky planets such as Earth or Mercury to lie on this plot?
4. Choose one small planet and one giant planet from the diagram and compare them in one sentence.

Density clue Two planets can have a similar radius but very different masses. A planet with more mass for the same radius is denser, which often suggests a rock-rich or iron-rich composition rather than a thick gaseous envelope.

PART D — Kepler’s third law in real data

15 min

Open Plots → Scatter. Plot orbital period versus semi-major axis and switch both axes to log scale.

Suggested workflow

- First look at all planets in the database.
- Then try a filter for one system. Example query: "trappist" IN name
- Compare the global plot with the filtered system.

Questions to answer

- What overall trend appears between period and semi-major axis?
- Why does a log–log plot help you see this relation?
- Do planets in a single system follow the same trend?

Optional challenge For planets orbiting the same star, Kepler’s third law gives approximately a ∝ P^(2/3). If the period is multiplied by 10, the semi-major axis should be multiplied by about 10^(2/3) ≈ 4.6. Does that match the trend you see?

Part D — brief conclusion

Math connection On a log-log plot, a power law becomes a straight line. For planets orbiting the same star, Kepler's third law predicts a slope close to 2/3 in the period-distance diagram. This is why the plot is so useful for spotting the relation quickly.

WRAP-UP — Synthesis and extension

10 min

1. Write one clear physical trend that you observed in the database.
2. Write one clear observational bias that affects the catalogue.
3. Which family of exoplanets seemed easiest to identify in the plots?
4. In 4–5 lines, explain why real astronomical data are powerful but must be interpreted carefully.

Final conclusion

Extension activity Use a scatter plot with x = semi-major axis, y = mass and point size = eccentricity. Try to locate 51 Peg b (a = 0.05 AU; m = 0.47 MJup) and Kepler-10 b (a = 0.017 AU; m = 4.6 MEarth). What do these two planets tell you about the diversity of planetary systems?

MINI GLOSSARY

Semi-major axis	The average distance between a planet and its star, usually measured in AU.
Eccentricity	A number that describes how circular or elongated an orbit is. e = 0 means a circle.
Log scale	A scale where equal spacing means equal multiplication, not equal addition.
Detection bias	A distortion caused because some planets are easier to detect than others.

Useful links and note on the data

- Database and online plots: https://exoplanet.eu/ and https://exoplanet.eu/plots/
- Educational framework: https://exo4edu.eu/
- The catalogue is regularly updated, so exact numbers can change from one class session to the next.