

A questionnaire-based study to understand knowledge and create awareness on the exoplanet-Kepler 1649c.

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I. Introduction

An Earth-sized exoplanet, Kepler-1649c, was identified by NASA's Kepler space telescope as the system's outermost planet, circling a red dwarf star, Kepler-1649, in its habitable zone. It is situated in the constellation Cygnus and is roughly 301 light-years (92 pc) away from the surface of our planet (Andrew, 2020). K2 Science Office director Jeff Coughlin called it the "most Earth-like planet" identified by the Kepler Space Telescope as a "similar planet to Earth." Initially, the planet was marked as a false positive by Kepler's robovetter algorithm (Doyle, 2020). The most well-known question of all time is whether life exists outside our planet. Given the size of the world and the fact that we are a dot in the vast sky, there must be some source of habitation outside of the Earth. The Kepler 1649 system was discovered in 2017 and significantly contributed to the Kepler mission's search for terrestrial exoplanets. This recently discovered world is 300 light years from Earth and revolves around a star with a radius of one-fourth that of the Sun. The Kepler-1649c is the exoplanet most like Earth in many ways among the 5000+ exoplanets (Exoplanet, 2020).

II. Review of Literature

The most Earth-like planet ever found is Kepler 1649c. The planet's diameter is only 6% larger than Earth's, and its host star provides it with 74% of the light and heat that the Sun provides to Earth. This suggests that the temperatures in the two worlds are comparable. There is a range of distances between Kepler 1649c and its host star where liquid water might exist on the planet's surface (Exoplanet, 2022). Compared to Earth, the exoplanet is only 1.06 times larger. It has a radius that is 1.02 times greater than Earth's. Kepler 1649 c orbits its host star, an M-type dwarf, every 19.5 Earth days (red dwarf). Kepler 1649 c is composed of sand and gravel. Exoplanets that are hotter than Earth likely to be rocky. Several nearby transiting planets exist in Kepler-1649, as in other Kepler systems, particularly those in the mid-M dwarf class (TechCrunch, 2020). Coplanar multi-transit systems tend to have only a tiny area in mutual inclinations or intersections.

In the Kepler system, Kepler 1649 c and b are neighbouring exoplanets. Only 0.08 per cent of the period ratio between Kepler-1649 b and c is close to a 9/4 ratio (NASA, 2020). This ratio shows that the inner planet orbits the host star about nine times for every four times the outer planet in the system. A planet's orbital resonance is shown by its integer period ratio to its nearest neighbour. Resonance occurs when two bodies in orbit exert gravitational forces on each other. However, the 9:4 resonant frequencies are not considered substantial. In general, planets are discovered near strong resonances, such as 3:2 integer ratios, where they can be found.

A third planet could exist in the vicinity of Kepler-1649 b and c, forming an orbital chain of 3:2 resonances. With a potential third planet, Kepler-1649b and c may be in a three-body Laplace resonance for about 13 days (NASA, 2020). There were no more than 600 ppm transits in the planet with this orbital period's Kepler light curve. Therefore, it is challenging to utilize Kepler's transit method on a third planet that orbits between Kepler-1649 b and c because it is too small to detect or has an orbital inclination that prevents it from being detected (Rice, 2020). Nonetheless, this system offers another illustration of a planet the size of Earth orbiting a red dwarf star in the habitable zone.

Planets must orbit their parent star very near to see it clearly from their perspective. There is a chance that life could exist on this planet because it's in a suitable temperature range. A growing body of evidence suggests that planets like this often exist among red dwarfs. Exoplanets up to Earth's size are more likely to be found near these stars as more data becomes available. It is more likely that one of these small, potentially livable and rocky planets isn't too dissimilar from our Earth when there are so many red dwarfs around." According to NASA astrophysicist Vanderburg. That Kepler 1649c's star is barely 20% and 0.5 per cent as massive or luminous as our own is not mentioned in many prominent web articles about this finding.

Kepler 1649c is ruled out of the habitable zone by its host star's extreme UV properties. It is a topic I touched on in both my book, *Improbable Planet8*, and a 2016 essay (NASA, 2020). All life forms must exist on a planet concurrently in both the liquid water and UV habitable zones. Kepler 1649c is the only one that does. Kepler 1649c has two halves, one of which will be extremely cold and the other scorching hot due to tidal locking (Van de Velde, 2018). The exoplanet's atmosphere is also a mystery to scientists, which could impact the planet's temperatures and ability to support life. On top of that, Kepler-1649c has a year that is only 19.5 days long due to its narrow orbit around its host star.

Kepler-1649c is a good contender for habitability, but there are other clues. Although automated approaches have improved, this discovery shows that human examination is still essential and suggests that terrestrial planets orbiting M-dwarfs are more numerous than those around more massive stars (NASA, 2020). We should expect new and exciting findings every year from the data collected by missions like Kepler and TESS as scientists continue to improve their capacity to search for potentially habitable planets. Scientists require additional data on Kepler-1649c before drawing any conclusions about whether or not life could exist there. The atmosphere of this exoplanet, which could impact the planet's temperature, is unknown at this time. However, this second planet orbits the star at a distance of around half that of Kepler-1649c (Wall, 2020). The orbital period ratios of the two planets are practically perfect. A planet revolves around its star four times, while the inner planet does so almost precisely nine times. In NASA's opinion, the ratio's stability indicates that the system is sound and will last long.

The fact that the recently found exoplanet has conditions very similar to those found on Earth has piqued the scientific community's interest in this new find. Several other exoplanets like TRAPPIST-1f and Teegarden c have dimensions that are thought to be more comparable to those of Earth. Some others, like TRAPPIST-1d and TOI 700d, may have temperatures more similar to those on Earth. However, there is no way to eliminate the possibility of Kepler discovering false positives in the data it collects. Several objects in space can cause stellar brightness, in addition to the planets that orbit the star themselves.

Additionally, the Kepler False Positive Working Group was established as a group with the mission of identifying false positives. According to the latest study recently published in the *Astrophysical Journal Letters*, the same group of researchers discovered that Kepler-1649 had been incorrectly dismissed as a false positive (NASA, 2020). Like our solar system, the star Kepler-90 is home to eight planets. Planets closest to the star tend to be smaller and stonier, whereas planets farther away tend to be larger and more gaseous.

III. Methodology

To understand the awareness of Kepler-1649c, identified by NASA's Kepler space telescope, amongst teenagers between the ages of 15-18years, a simple questionnaire-based study was conducted from July 2022 – Aug 2022. This study was conducted in the form of a simple survey which was self-designed.

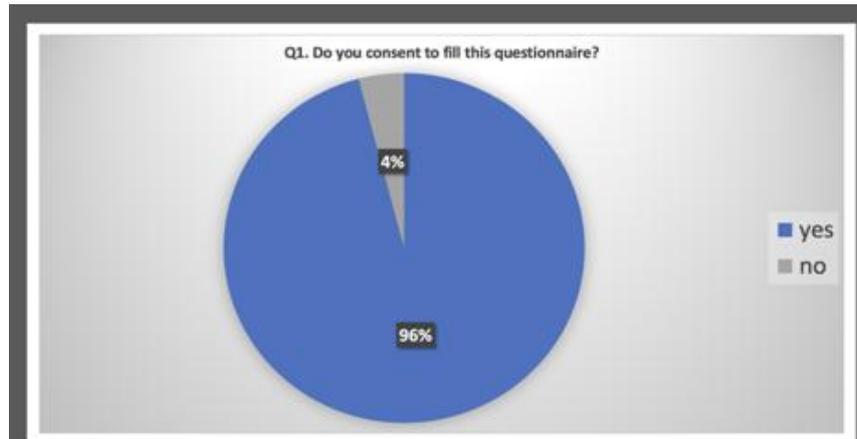
The objective of this survey was to generate data that shed light on teenagers' awareness of Kepler-1649c. In this survey, five questions were designed and circulated electronically as an online link via all platforms of mail and WhatsApp messaging platforms to facilitate the feasibility of filling the questionnaire.

This online link was then circulated amongst peers ranging from the age of 15-18years, and only those who provided consent proceeded to fill the complete questionnaire. The link was shared with 51 teenagers for two months, of which 49 filled the questionnaire. Of the 49 participants who provided their consent, they proceeded to fill out the questionnaire. In these participants, their general belief on whether life exists outside Earth, their awareness of NASA's discovery of Kepler 1649c and their awareness of other habitable planets was collected.

The period taken for this study was limited to only two months, which proved to be enough time to gather all the information needed in this research. The research objectives were met during this study period since a reliable size of peers was reached. In addition, the study limited the research to peers ages fifteen to eighteen, regarded as the most proactive age. The feedback from the peers involved in the survey shows a constructive representation of a larger sample of peers. In analyzing the data, different pie charts were drawn with each pie chart representing; whether the participants gave consent to fill the questionnaire, the general belief on whether life exists outside Earth, their awareness of NASA's discovery of Kepler 1649c, whether the participants understood the meaning of light years, and their awareness of other habitable planets respectively. The following section displays the results of this study.

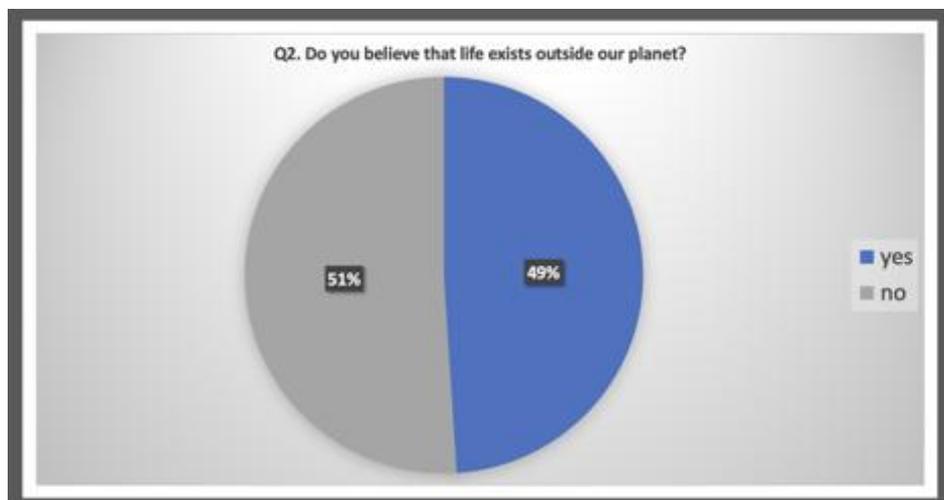
IV. Results

In the chats below, different colours are used to highlight the response from the peers. Also highlighted in each chat is the percentage indicating the degree of different opinions from the participants in the study.



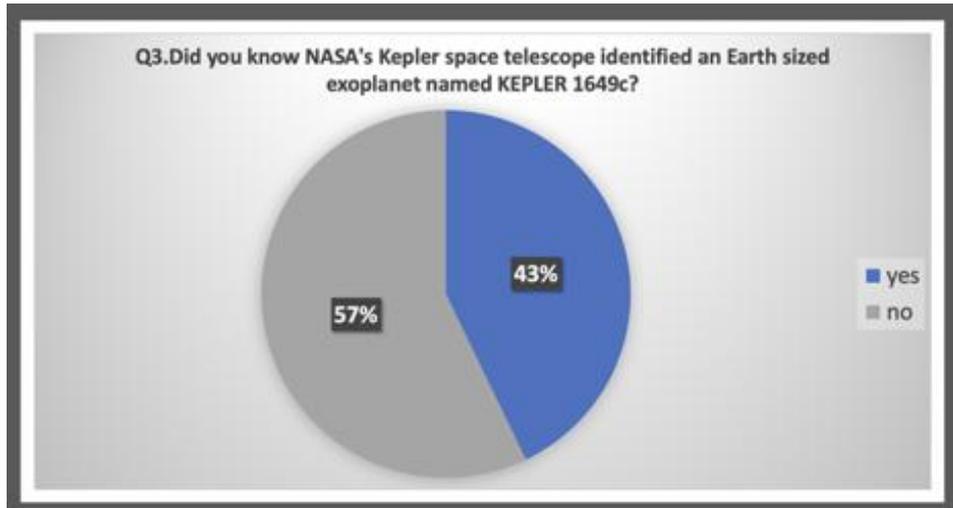
Graph 1: A bar chart representing the percentage of peers who gave and failed to give consent to fill the questionnaire.

This graph shows that a large percentage of the participants gave consent to fill out the questionnaire. This indicates that most peers were interested in being involved in the study.



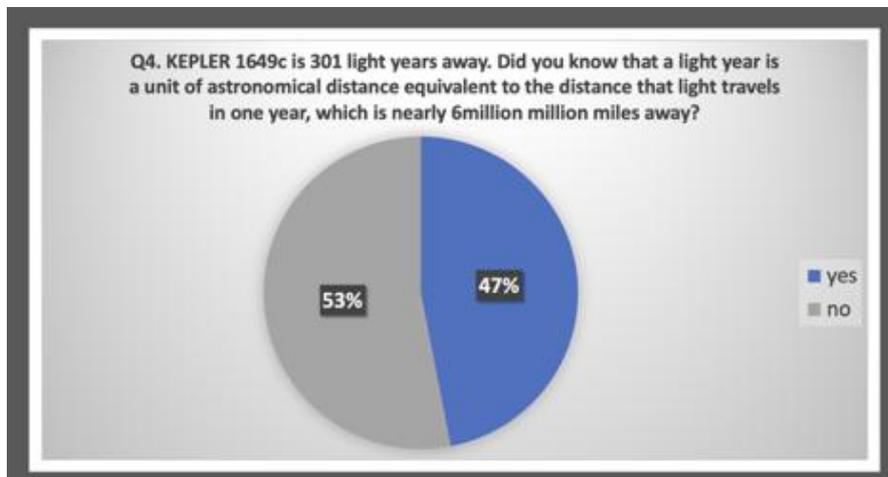
Graph 2: A bar chart representing the percentage of peers who believe life exists outside Earth.

From this graph, it is evident that a majority of the participants in the study did not believe that there was a possibility of life existing outside our planet.



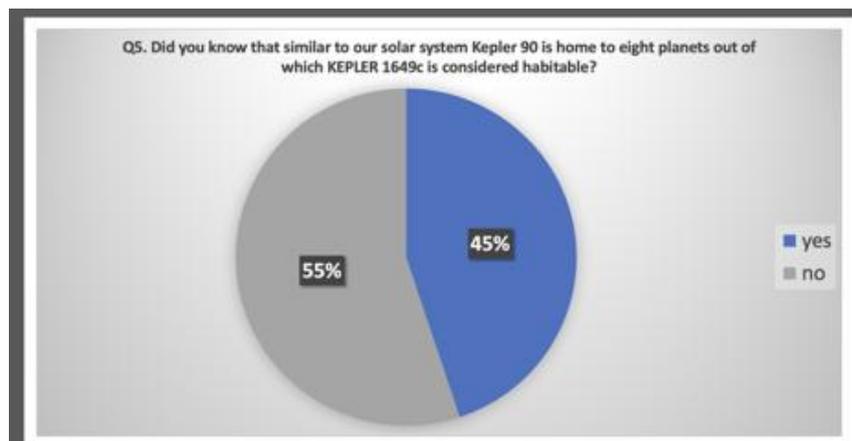
Graph 3: A bar chart representing the percentage of the peers' knowledge of KEPLER 1649c

As seen from the above chart, most of the study participants were unaware of the existence of an exoplanet named KEPLER 1649c.



Graph 4: A bar chart representing the percentage of peers who knew about the meaning of a light year.

As seen from the chart above, a majority of the participants in the study did not know that a light year is a unit of astronomical distance equivalent to the distance that light travels in one year, which is nearly six million miles away.



Graph 5: A bar chart representing the percentage of peers' knowledge of KEPLER 1649c being habitable.

It is evident from the bar chart above that most of the participants involved in the study were unaware that, similar to our solar system, KEPLER 90 is home to eight planets, out of which KEPLER 1649c is considered habitable.

Although the time taken to carry out this study was enough, there was a low turnout in the number of peers interested in answering the questions. As indicated by the first chart, 96% of the peers consented to fill out the questionnaire. The total number of peers to whom the link was shared to was, however, only 51. It is worth noting that most of the peers engaged in the study were unaware of NASA's discovery of Kepler 1649c. In addition, the study revealed that most peers did not believe in the existence of life outside our planet.

From the results obtained in this study, there is a need for more training and education regarding NASA's developments and research. The results herein imply that additional research in the future will be limited since it is expected that most peers today will be the foundation of future research. Therefore, Peers need to be educated concerning the new developments by NASA and, in so doing, find solutions to human habitation in future on planets like KEPLER 1649c. Failure to educate the peers (who are expected to be future researchers) means that the main objective of this study will not have been achieved, which is to have Kepler - 1649c as the answer to finding habitation outside Earth.

V. Summary

From the results displayed above, 49 out of 51 agreed to provide their consent and fill out the questionnaire circulated via mail and message. These 49 proceeded to fill the rest of the questions. 51% of these participants believed that life does not exist outside Earth. 57% of the total teenagers who filled this questionnaire were indeed not aware that NASA's space telescope had identified an Earth-sized exoplanet named Kepler 1649c. 53% of participants did not understand the distance of Kepler 1649c and the meaning of "light years". Lastly, 55% were unaware that Kepler 1649c was considered habitable.

Although the number of peers involved in the study was small, it is evident that most of the peers involved were not knowledgeable about NASA's identification of an Earth-sized exoplanet named Kepler 1649c. From the feedback obtained, it is evident that had more peers been involved in the study, there are high chances that similar results would have been obtained. It is, therefore, necessary to carry out more awareness and educate the peers regarding NASA's developments.

VI. Conclusion

At the end of the 2-month duration of this study, the study's results depict the awareness of Kepler 1649c amongst teenagers. From the results obtained in the study, a more significant proportion of participants were unaware of NASA's discovery of the habitable Kepler 1649c, as depicted by the results. In addition, a higher proportion did not believe that life could exist outside Earth. Although a lower proportion of participants knew of Kepler 1649c and that it was considered habitable, >50% of participants were unaware. >50% of teenagers did not know that a light year is an astronomical distance equivalent to the distance that light travels in one year.

Since the study results show that a more significant proportion of teenagers were unaware of NASA's discovery of Kepler 1649c, there is a significant margin to increase awareness. The study reflects that some peers share my belief that life outside Earth is a distinct possibility, but even if they don't believe it, there should still be a greater awareness of the advancements in science. After all, the eyes only see what the mind knows.

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