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YOUNG GLOBAL SCIENTISTS

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contents

sciences

- Exploring possible chaotic and stable motions of Astrojax Pendulum, *Konurbayev Sardar* p. 1
- The Voices in My Head, Maha Sawhney p. 38
- Bias in Psychology and its Consequences, *Olivia Njideka Obi-Washington* p. 40
- Using Nighttime Light Data to Estimate the Impact of COVID-19 Vaccinations in the United States, *Basri Kerem Alhan and Nur Pakir* p. 43
- Evaluation of Levels of PFOA and PFOS in the Rivers of Chennai, TamilNadu, *Sanchita Sendil* p. 51
- Fuel Cell Research Project, *Sid Kadam* p. 66
- Ancient Cells, *Darcey Joia* p. 81

social sciences

- Parental Prejudice Towards the LGBTQ+ Community, *Olivia Jaramillo* p. 86
- The Reign of The Pharmaceutical Corporation, *Raj Rajput* p. 98
- Censorship - A Necessity or a Stifling of Freedom?, *ChingYi Vong* p. 102
- Witchcraft in Morocco, *Sarah Ouardaoui* p. 106
- Are demand-side policies the most effective method of increasing the level of national income/economic activity?, *Dishaan R Pandey* p. 108
- Effects of and Solutions to Economic Inequality, *Taehyun Sa* p. 113
- Impact of youth radicalism as a political movement on the Russian society, *Ekaterina Nizovtseva* p. 123

Physics

Exploring possible chaotic and stable motions of astrojax pendulum

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Abstract

This work studies the movement of a toy astrojax pendulum in space and what types of movement it can describe. Chaotic and stable motion systems were used to describe the entire system. The work was carried out to provide for more research on the topic and develop the understanding of a system as complex as astrojax. In the past, this topic has been understudied; thus, this research can be partially considered the first work in this area, though it has big assumptions.

Introduction

An interesting toy problem is an Astrojax pendulum. Astrojax is, in fact, a double spherical pendulum, in which the first swing is allowed to slide freely along the cable. Astrojax players can produce a lot of exciting and unexpected movements. After all, even without external coercion from the outside player, the movement of two beans exhibits confusing and chaotic behavior.

Oscillatory mechanical systems are a subset of dynamical systems that can describe the evolution of states for almost all physical phenomena. Fluctuations of various types are found in real mechanical systems, almost all of them are thermodynamically irreversible (due to damping, friction, energy loss for heat, etc.). This study investigates a set of coupled chaotic oscillations

formed by an astrojax pendulum. Pendulums are one of the most fundamental physical systems studied, and although they can be ordinary, they are ideal only in the simplest cases. While one pendulum one can simply solve the equations of motion, especially in the limit of small amplitudes, a "double" swingarm has a grip that gives go to chaotic behavior. But an astrojax pendulum can create both chaotic and stable movements. The astrojax system will be described by a system of differential equations and then described using a python program. Then an experiment will be carried out and a comparison between the results of the simulation and the experiment will be carried out. Thus, it can be understanded how much theory can describe the movements of the astrojax pendulum.

In the past, the question of the movement of the astrojax pendulum has been raised in two works. In the Astrojax pendulum and the n-body problem on the sphere: A study in reduction, Variational integration, and pattern Evocation, the system is described by Lagrangian mechanics, but it is not taken into account that the support can move. Also, the experiment does not fully show the similarity with the theory and what kinds of trajectories a toy can create. In the study of the astrojax pendulum, the system is described by Newtonian mechanics, but it is also not visible what types of trajectories the toy describes and how, in principle, it behaves. It also does not describe how a toy with a movable fulcrum will behave. In general, all the articles written in the past years consider a special case of a toy in which only the upper ball moves and does not show how the system can behave under different initial conditions. This work will study the astrojax pendulum in general, describing movements with a movable fulcrum and a moving upper

ball. We will also consider all types of trajectories that can form and how the system will behave as a whole.

Theory

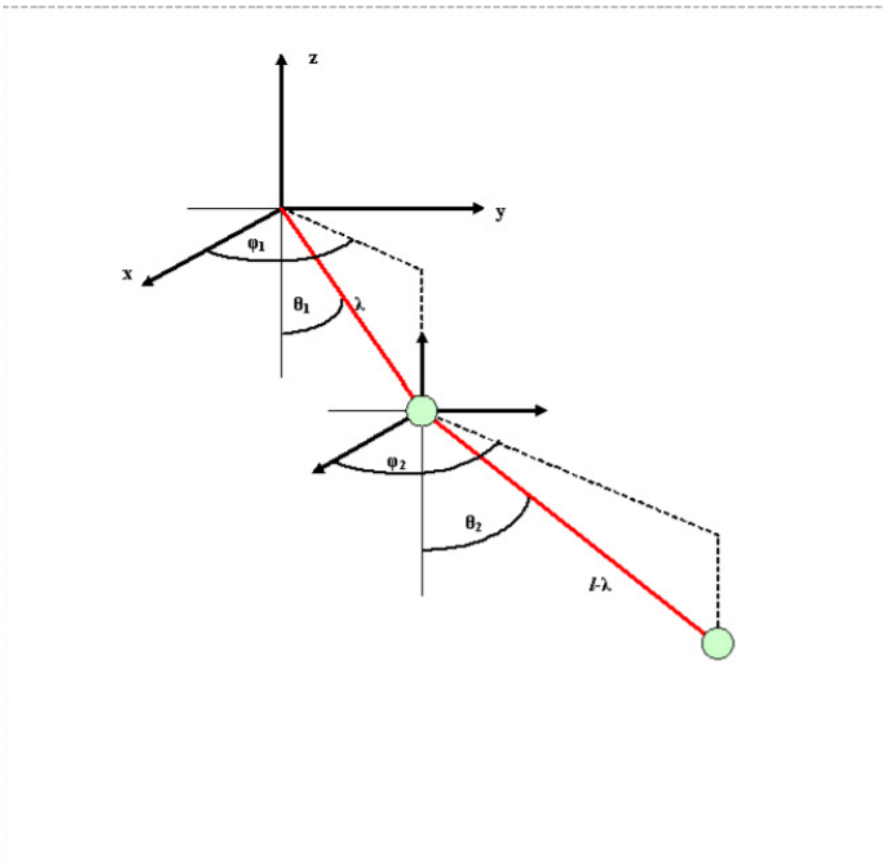

Figure 1: The Astrojax Pendulum

A force is applied to the end of the rope to make the balls move and create different trajectories. This toy is called an astrojax pendulum. Due to the different movements of the end of the thread, the system can create two types of movement: chaotic and periodic.

Chaotic movement is a movement that a mathematical model cannot accurately predict and that a person cannot intuitively imagine. On the other hand, stable motion is a motion that can be accurately predicted by a mathematical model and describes trajectories that are intuitive to humans, such as a circle or an ellipse. Stable movement and chaotic movement are shown in Figure 2 and Figure 3, respectively.

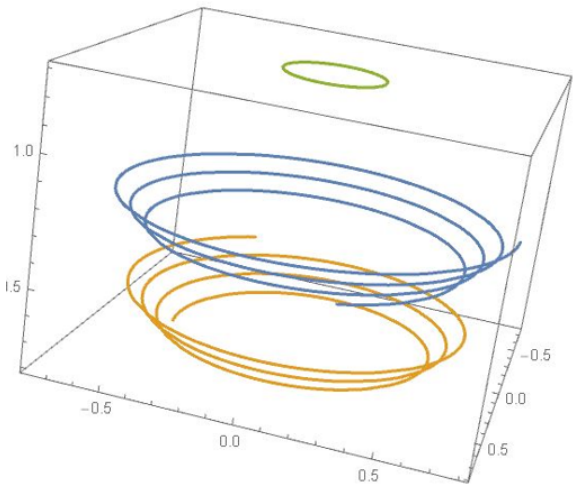

Figure 2 describes the stable motion where the green circle represents the trajectory of the end of the rope which rotates by the motor, blue and yellow describe trajectories of balls

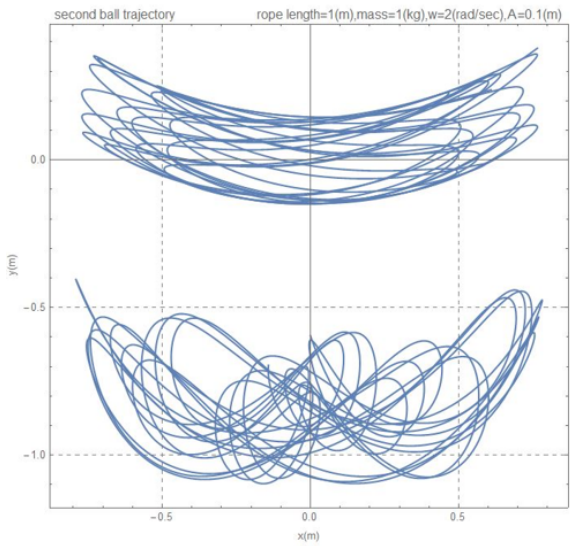

Figure 3 describes the chaotic trajectories of the second ball in x and y system

In the first part of the theory, a model for orbital motion will be presented. In the second part of the theory, the chaotic movement of an astrojax pendulum will be presented.

Orbital Motion

When the top end of the rope rotates, it is noticeable that the toy itself behaves stably and predictably. Balls create orbital trajectories that can be predicted by a mathematical model.

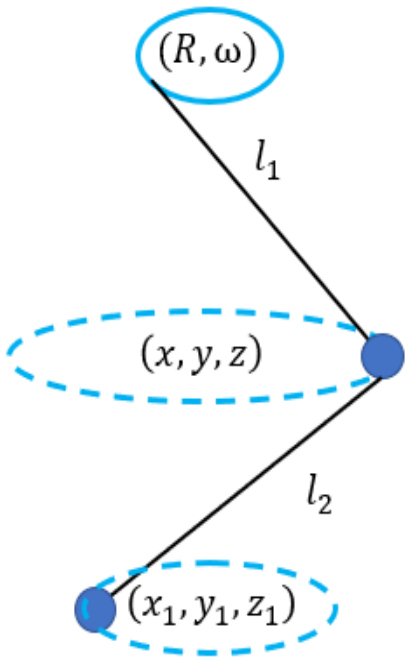

Figure 4: describes the entire pendulum system. R is the radius of motor trajectory, ω is the angular velocity of trajectory, l_1- length between end and first ball, l_2- length between the first and second ball

In Figure 4, a diagram of the entire system is shown. When the end of the rope begins to rotate in a circle of a certain radius with a certain angular velocity, the lower balls also begin to rotate in a circle. The system has no choice regarding rotation because of the angular momentum. According to the law of conservation of momentum, the angular momentum created by the rotation of the end must remain unchanged. Therefore, the balls begin to spin.

To describe the movement of the balls, it must be clarified why first the ball will not move up and down. This is possible only when the centripetal force is greater than or equal to the difference between the mass of the ball and the friction of the thread on the ball. In this model, the tension of the thread above and below the ball will play an insignificant role due to the centripetal force.

$$Fsin\theta \gg mgcos\theta - F_{friction} \tag{1}$$

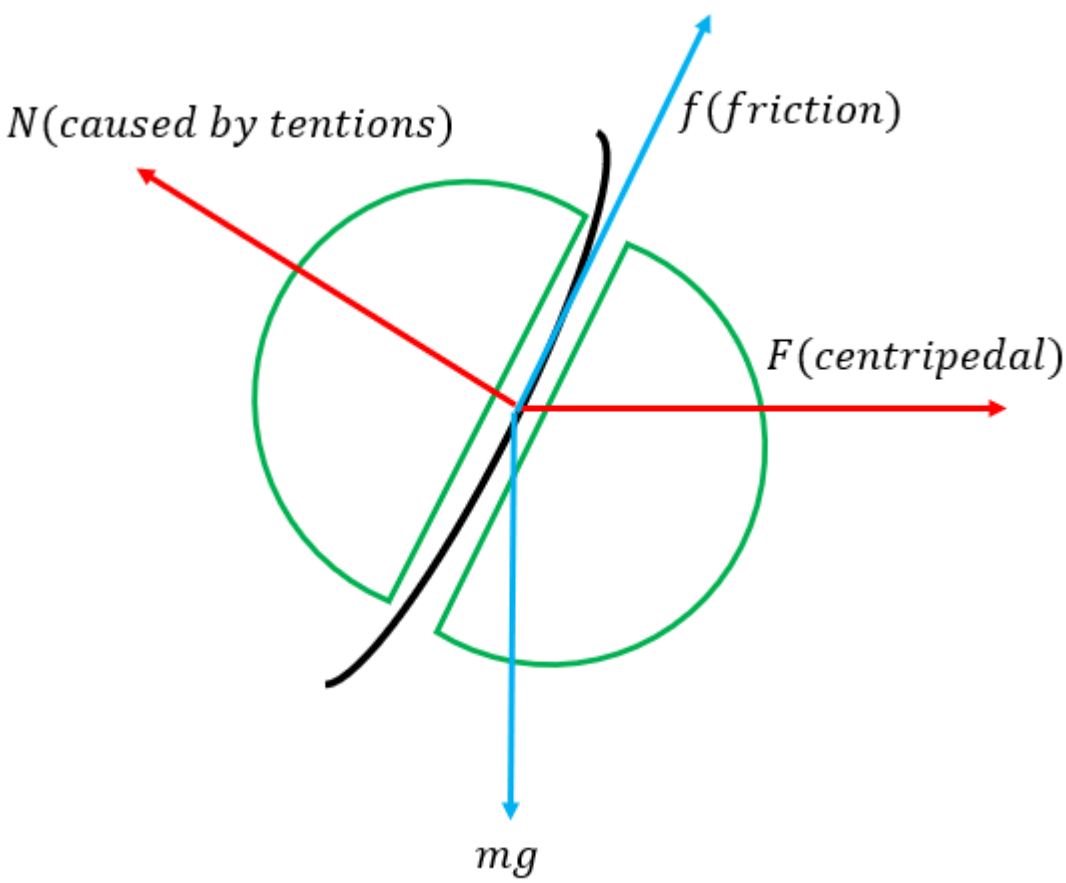

Figure 5

Figure 5 schematically shows the forces acting on the ball: downward gravity, friction in the direction of the rope, centripetal force and support reaction force generated by the tension on the rope. As already mentioned, if the projection of the centripetal force is greater than the difference between the ball's mass and friction, then the ball will be at rest and the motion will be stable. However, options for exclusion are not excluded when the ball starts moving downward, and this will lead the system into chaos.

The force of air resistance should also be taken into account. Since the balls rotate in the air, the drag force can be written as the formula below. Let's write down the dependence of distance, time, and momentum on time

$$dl = vdt \tag{2}$$

$$dm = \rho Avdt \tag{3}$$

$$dp = \rho Av^2 dt \tag{4}$$

Now, using Newton's second law in impulse form, we write down the formula for the drag force, inserting the result from equation (3) into (4)

$$F = \frac{dp}{dt} = 2\rho Av^2 sin^2\theta \tag{5}$$

It is now noticeable that the force of air resistance depends on the surface area of the surface of the ball, speed, angle of attack, and air density. To simplify the model, the angle of attack will be 90 degrees. Later in the experiment, it will be possible to say exactly how accurately the angle of attack was chosen.

Now, to calculate the area, we integrate over the phi angle as shown in the picture.

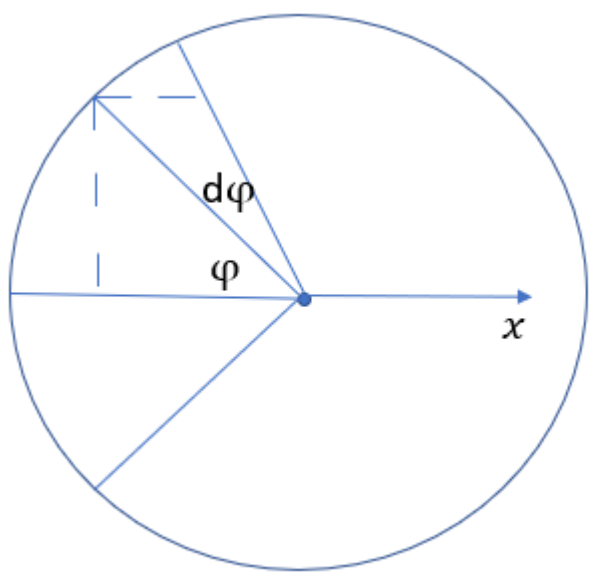

Figure 6: integrating over the whole sphere from 0 to pi/2

$$dF = 2\rho dAv^2 \tag{6}$$

$$dA = 2\pi r^2 sin\varphi d\varphi \tag{7}$$

Substituting dA into the equation (5) and integrating from 0 to $\frac{\pi}{2}$,

$$dF = 2\pi r^2 \rho v^2 \int_0^{\frac{\pi}{2}} sin\varphi d\varphi \tag{8}$$

$$F = 2\pi r^2 \rho v^2 \tag{9}$$

Since this is the force of air resistance, it is necessary to enter a correction factor that is equal to the Reynolds number

$c \approx Re$

$$F = c2\pi r^2 \rho v^2 \tag{10}$$

$$Re = \frac{\rho v l}{u} \tag{11}$$

where ρ is the density of fluid;

υ is the velocity of the fluid;

l is the diameter of the pipe;

μ is the dynamic viscosity of the fluid.

Now It is possible to write Newton's second law to describe this system in three planes: x, y and z. Friction forces, centripetal force, resistance force were taken into account. Since the changes occur along with the x and z coordinates, it is necessary to add the ratio of the

coordinate with the angular velocity and radius of the circle that describes the motor shown in the picture below. The phi and theta angles refer to the first ball, and the alpha and beta angles refer to the second ball.

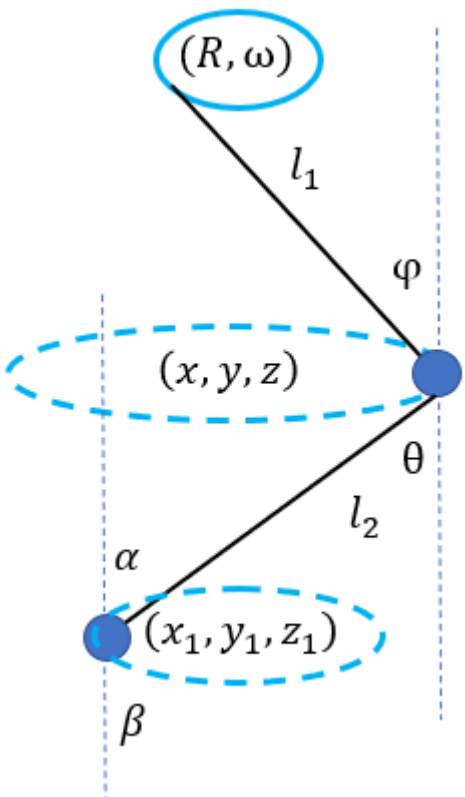

Figure 7: describes a stable system with and theta angles

Below is the equation for the x coordinate:

$$m\frac{d^2x}{dt^2} = T_1 cos\theta cos\varphi + T_2 cos\alpha cos\beta + mR\omega^2 cos\omega t - c2\pi r^2 \rho v^2$$

(12)

$$\frac{d^2x}{dt^2} = \frac{d^2}{dt^2}(l_1 cos\theta sin\varphi) \tag{13}$$

As can be seen from the equation, the resistance force is directed opposite to the motion of the ball. Now let's write down the equation in the y coordinate. It will have downward gravity.

$$m\frac{d^2y}{dt^2} = T_1 cos\theta sin\varphi + T_2 cos\alpha sin\beta - mg - c2\pi r^2\rho v^2 \tag{14}$$

$$\frac{d^2y}{dt^2} = \frac{d^2}{dt^2}(l_1 cos\theta cos\varphi) \tag{15}$$

And the equations for the z coordinate

$$m\frac{d^2z}{dt^2} = T_1 sin\theta cos\varphi + T_2 cos\alpha sin\beta + mR\omega^2 sin\omega t - c2\pi r^2\rho v^2 \tag{16}$$

$$\frac{d^2z}{dt^2} = \frac{d^2}{dt^2}(l_1 sin\theta cos\varphi) \tag{17}$$

It is noticeable that the tension force differs from above and below one of the balls due to the bending of the thread inside the ball during rotation. The tensile and centripetal forces themselves form the rotational movements, while the resistance force prevents this. Phi and theta were used for Ball 1, while alpha and beta were used for Ball 2. However, since the

tension of the threads depends on both balls in the equations of motion regarding Ball 1, the angles alpha and beta are also present.

Now the equations of motion for the second ball are written down. It is noticeable that the trajectory of the ball, as in reality, is affected by the movement of the first ball.

$$m\frac{d^2x_1}{dt^2} = T_2 cos\alpha cos\beta - m\frac{d^2x}{dt^2} - c2\pi r^2\rho v^2 \tag{18}$$

$$m\frac{d^2y_1}{dt^2} = T_2 cos\alpha sin\beta - mg - m\frac{d^2y}{dt^2} - c2\pi r^2\rho v^2$$

(19) $$m\frac{d^2z_1}{dt^2} = T_2 cos\alpha sin\beta - m\frac{d^2z}{dt^2} - c2\pi r^2\rho v^2$$

(20)

$$\frac{d^2x_1}{dt^2} = \frac{d^2}{dt^2}(l_2 cos\alpha sin\beta) \tag{21}$$

$$\frac{d^2y_1}{dt^2} = \frac{d^2}{dt^2}(l_2 cos\alpha cos\beta) \tag{22}$$

$$\frac{d^2z_1}{dt^2} = \frac{d^2}{dt^2}(l_2 sin\alpha cos\beta) \tag{23}$$

Since these systems of equations are quite complex, I wrote a program to solve and visualize these equations. As these are differential equations, the initial conditions were set coinciding with the experiment. At the very beginning, all angles were 0 degrees. After the end began to rotate, the angles began to change.

Some preliminary conclusions can be drawn so far. The angular velocity remains constant throughout the flight. The starting radius of one ball will decrease over time, while the radius of the two balls will increase. It is also possible to conclude that, with sufficiently large omega balls, a different trajectory will occur due to the tension of the rope, the ball shedding and the possible small vibrations

Chaotic Motion

To describe chaotic movements, one must understand that Ball 1 will move along the rope. Let us describe its movement.

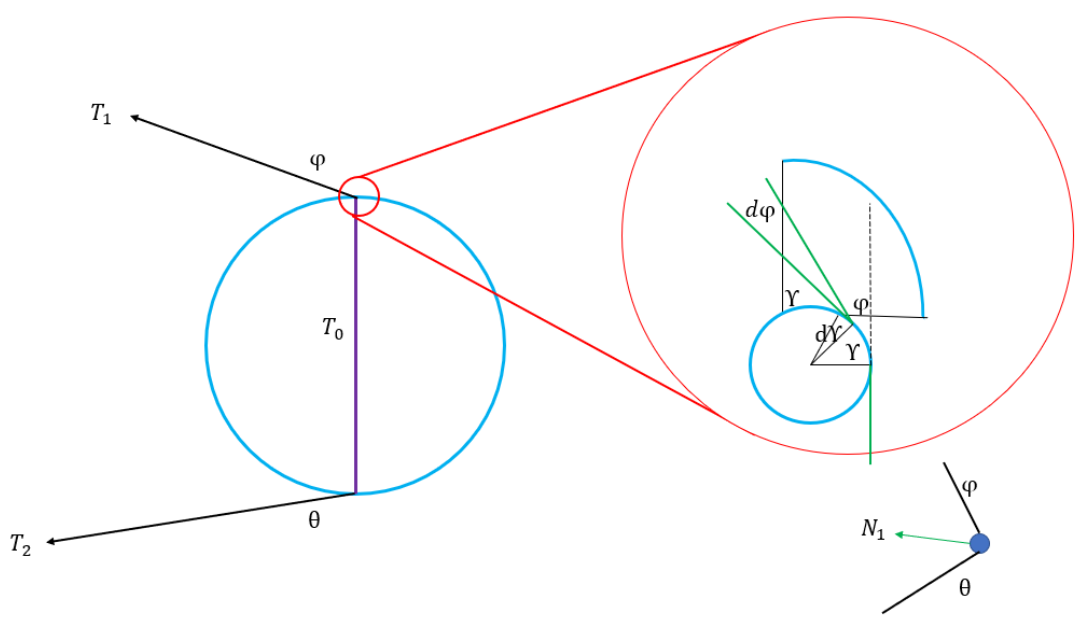

Figure 8

As seen in Figure 8, different tensions will form at the ends of the ball due to the second ball and the bending of the thread inside the ball. To describe the tensions being formed, it is necessary to enter the theta and phi angles describing the bends at the upper and lower ends. There is also a nominal thread tension, which is constant. Given that the angles change, one can integrate over the angle to find the dependence of the tension on the angle. The formulas are given below.

$$T_0 = T_1 e^{\mu(-\varphi)} \tag{24}$$

$$T_2 = T_1 e^{\mu(-\theta)} \tag{25}$$

As it can be seen, the pattern is inversely exponential, and it is possible that, at high angles, the tension will drop. This can just cause the ball to fall.

The reaction force of the support also needs to be considered. This force is the tension force on the thread. This is exactly how the ball interacts with the thread. To introduce the reaction force of the support, one also must enter the alpha angle describing the bend of the thread at the top of the ball.

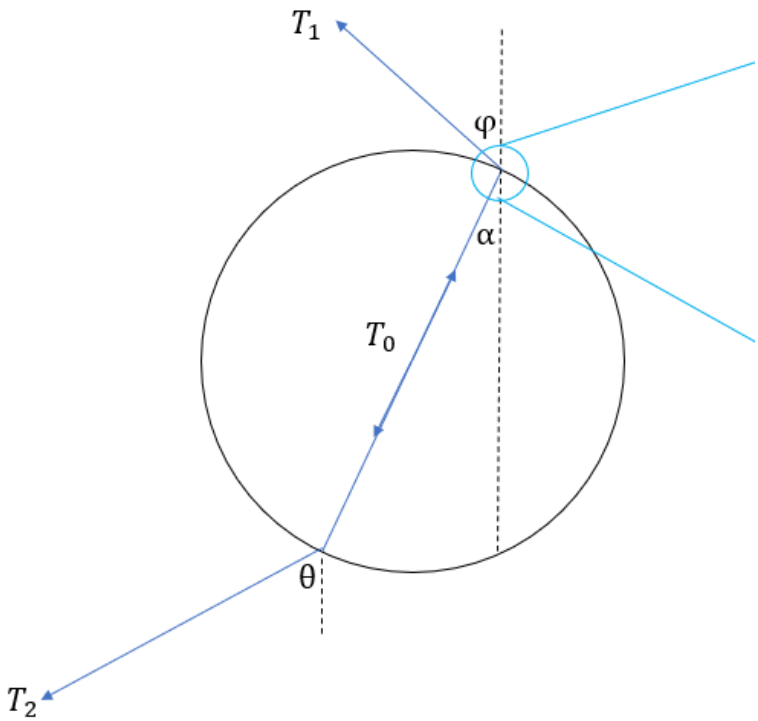

Figure 9: here introducing angle alpha, which describes the movement of rope inside the ball

After the introduction of the angle alpha, the equation for the reaction force of the support can be written.

$$N_1 = (T_1 + T_0)sin(\frac{\varphi+\alpha}{2}) \tag{26}$$

However, for a more accurate description, it is necessary to take into account the friction force of the thread on the ball.

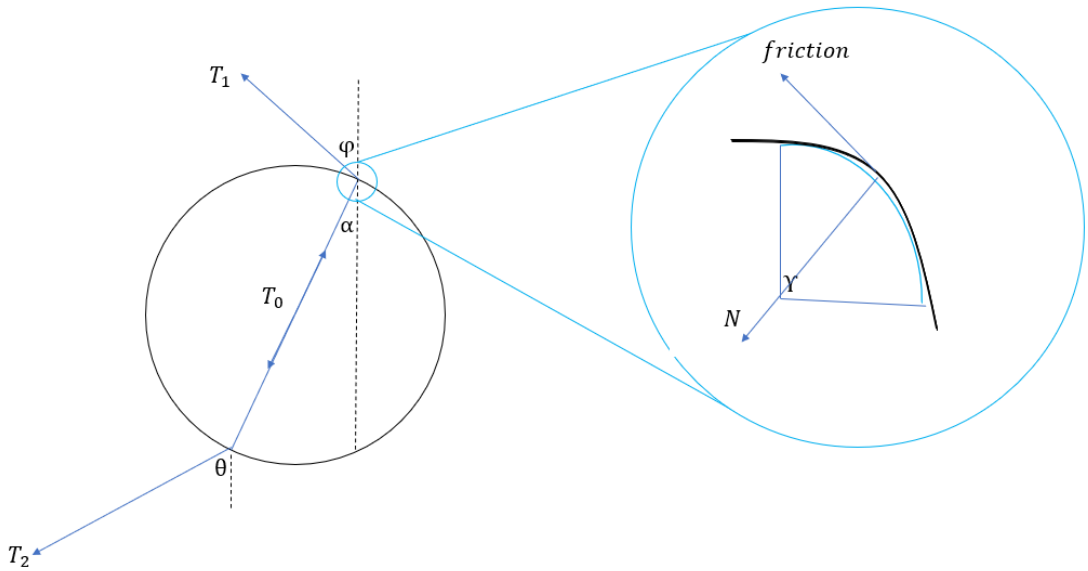

Figure 10:here introducing friction between ball and rope

As seen in this figure 10, the friction force is directed along the line of the thread at the top of the ball and plays a role in keeping the ball in a state of equilibrium or creating small vibrations. Now that the frictional force is considered, one can rewrite the equations and enter the reaction force of the support created by this friction.

$$T_0 = T_1 e^{\mu(\pi-\alpha-\varphi)} \tag{27}$$

$$N_1 = (T_1 + T_0) sin(\frac{\varphi+\alpha}{2}) \tag{28}$$

$$T_2 = T_1 e^{\mu(\pi+\alpha-\theta)} \tag{29}$$

$$N_2 = (T_0 + T_2) sin(\frac{\theta-\alpha}{2}) \tag{30}$$

Now, considering friction and the fact that the tension of the threads is different at the ends, one can apply the Kabstan equation. A revised version of this equation was used for this case. There are no major differences.

$$R(T_2 sin(\theta - \alpha) + T_1 sin(\varphi + \alpha) + \mu N_1 sin(\frac{\varphi+\alpha}{2}) + \mu N_2 sin(\frac{\theta+\alpha}{2})) = I\frac{d\omega}{dt}$$

(31)

There is a dependence of the tension of the threads, which refers to the movement of the ball itself upon rotation. Considering the force of air resistance derived in the last part, the equations of motion describing this system can be written.

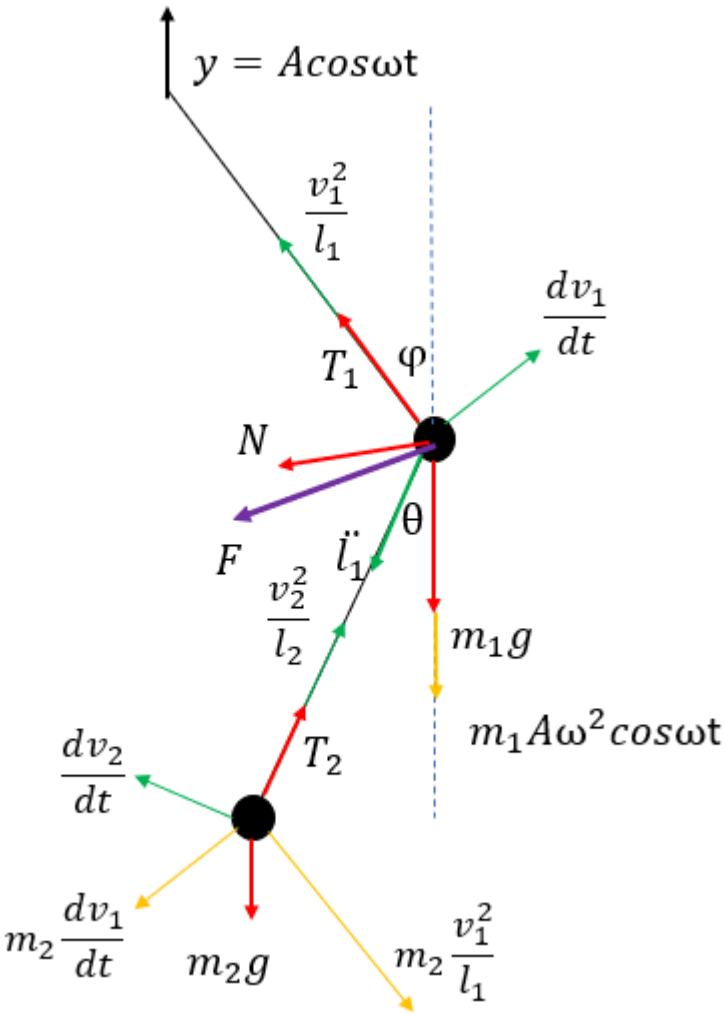

Figure 11: full chaotic system with forces applied to each ball and the rope

As seen in this figure 11, the rope length differential was introduced because the ball moves along it. The forces acting on the balls were described. These are resistance forces, designated F and F1, acting against the movement of the ball. The forces of gravity of the balls, m1g,and m2g, are directed downward. The tension forces, T1 and T2, are directed along the threads

and centripetal forces. Also, the forces created by vertical oscillatory movements still act as y = Acoswt.

These are the equations of motion. The basis equation was Newton's second law.

$$\frac{V_2^2}{l_2} = \frac{T_2}{m_2} - \frac{dV_1}{dt}cos(\theta + \varphi) - gcos\theta - \frac{V_1^2}{l_1}cos(\theta + \varphi) \tag{32}$$

$$\frac{dV_1}{dt} = \ddot{\varphi} l_1 + \dot{l}_1 \dot{\varphi} \tag{33}$$

$$\frac{dV_2}{dt} = \ddot{\theta} l_2 + \dot{l}_2 \dot{\theta} \tag{34}$$

$$\frac{dV_2}{dt} = \frac{dV_1}{dt}cos(\theta + \varphi) - gsin\theta - \frac{V_1^2}{l_1}sin(\theta + \varphi) - F_1 \tag{35}$$

$$gsin + \frac{N}{m}sin\frac{\varphi + \theta}{2}(1 - \mu) + A\omega^2 Cos\omega t Sin\varphi - F = \frac{dv_1}{dt} + \ddot{l}_1 Sin(\theta + \varphi) \tag{36}$$

$$gsin + \frac{N}{m}sin\frac{\varphi + \theta}{2}(1 - \mu) + A\omega^2 Cos\omega t Sin\varphi = \frac{dv_1}{dt} + \ddot{l}_1 Sin(\theta + \varphi) \tag{37}$$

Since this is a system of differential equations, the only way to solve this numerical solution is by programming the system. Therefore, this system was solved numerically.

Now it is necessary to describe the dependence of the coordinates of the balls in the x and y plane for a more accurate description of the model and understand the system of motions and the initial

conditions for solving differential equations. Without these data, the solution of differential equations is not possible.

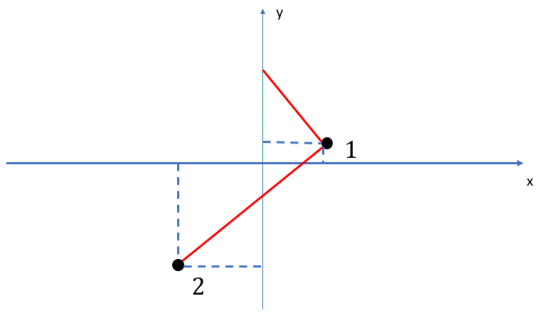

Figure 12

As seen in this figure 12, the coordinates themselves were calculated taking into account the angles that are already in theory and the oscillations of the end to produce an accurate description of the movement.

$$x_1 = l_1 sin\varphi \tag{38}$$

$$x_2 = l_2 sin\theta - l_1 sin\varphi \tag{39}$$

$$y_1 = l_1 cos\varphi - Acos\omega t \tag{40}$$

$$y_2 = - l_2 cos\theta - l_1 cos\varphi + Acos\omega t \tag{41}$$

Now knowing the coordinates, one can calculate the Lyapunov exponent. Its meaning and the interpretation of the results will be presented in the Experiment and Discussion section. It is possible to assume that the system, which looks chaotic, can be partially predicted and everything can converge at one point.

Method

A physical model of the astrojax pendulum toy was investigated for chaotic movement and stable movement. To confirm the theory, one must study the trajectory of the balls. Later, comparing the trajectory of the balls, it can be concluded that the theory is reliable.

To more accurately study the behavior of the system, the constants must be changed, namely the ratio of the masses of the balls, the initial distance between them, the speed of rotation or vibrations at the end of the thread, and the thread itself. This will change the coefficient of thread tension.

For the experiment, a system of rope with two balls was used. One is attached to the end and the second can freely move along the rope attached to the mechanism of rotation or create vibrations along a rolled line. On the side and below, there are fast cameras that record the movements of the balls and the tracker program, which draws the trajectory.

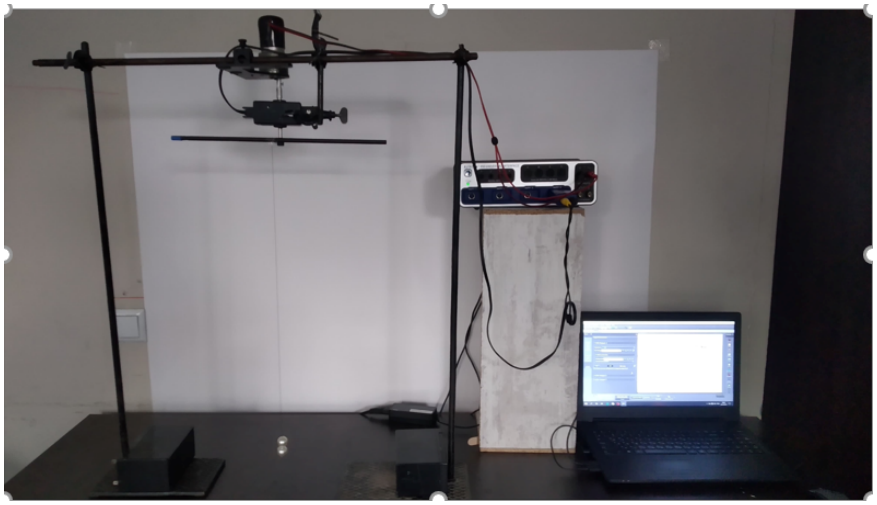

Figure 13: Full system of motor, DC power supply, and computer with program tracker that tracks system

The picture above shows the setup for the experiment. Above, there is a motor that rotates. The necessary mechanism is already attached to it to create rotation or oscillation. The laboratory power supply unit supplies the motor and, by changing the voltage, changes the rotation speed and the computer that the cameras, which record all movement, are connected to.

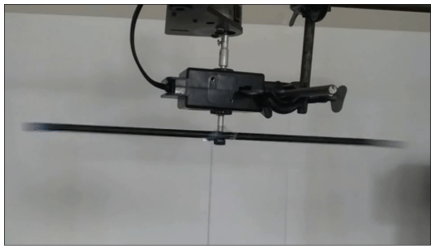

Figure 14

Figure 14 shows a blade attached to a motor. The thread is attached to the blade to create rotation and rotates along a certain radius at a certain angular velocity. The torque of the motor is transmitted to the blade. The thread is fixed at a certain level to rotate with a certain radius, thereby imitating the movements of a human hand.

While a different mechanism is used for vibrations, it is also attached to the motor. It is designed so that the torque of the wheel is transmitted at the linear moment of the part. Thanks to such a simple and well-known mechanism, it is possible to create vertical oscillations with the help of a motor. To measure the period of oscillation, tests were initially carried out and a table recording voltages, corresponding frequencies, and periods of oscillation was created. The mechanism diagram is presented below.

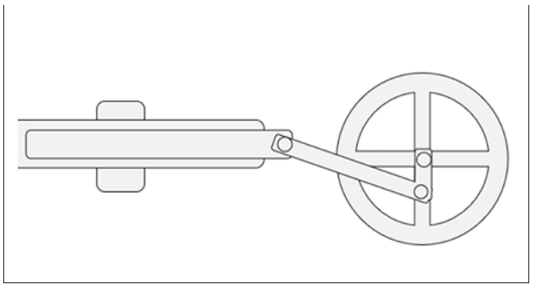

Figure 15: the diagram of the system that creates vertical oscillations

Two cameras and a tracker program on a computer were used to outline the trajectories to observe the balls. Below is a picture of the tracking of the balls.

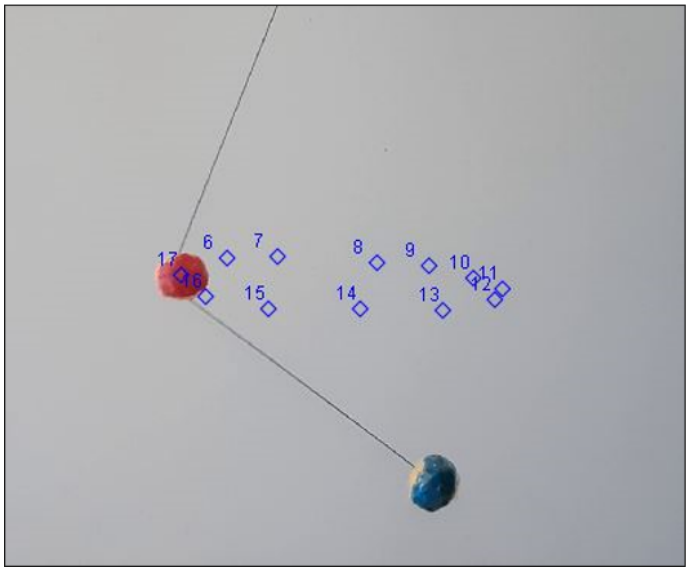

Figure 16: the program Tracker tracks the first ball

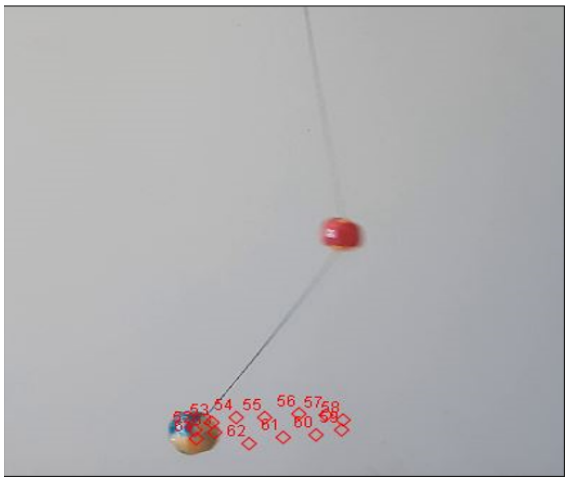

Figure 16: the program Tracker tracks the second ball

For theoretical graphs and trajectories of the balls, a program was written that visualizes the trajectories. Later, the data collected by the tracker program was interpreted into a schematic and applied to the main drawing. The program displays the coordinates, which are already applied to the theoretical data for analysis.

Results

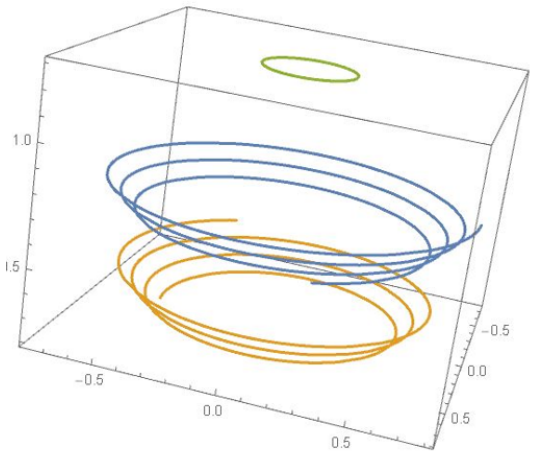

Figure 17: The result of the simulation of the stable motion where the green circle represents the trajectory of the end of the rope which rotates by the motor, blue and yellow describe the trajectories of the balls.

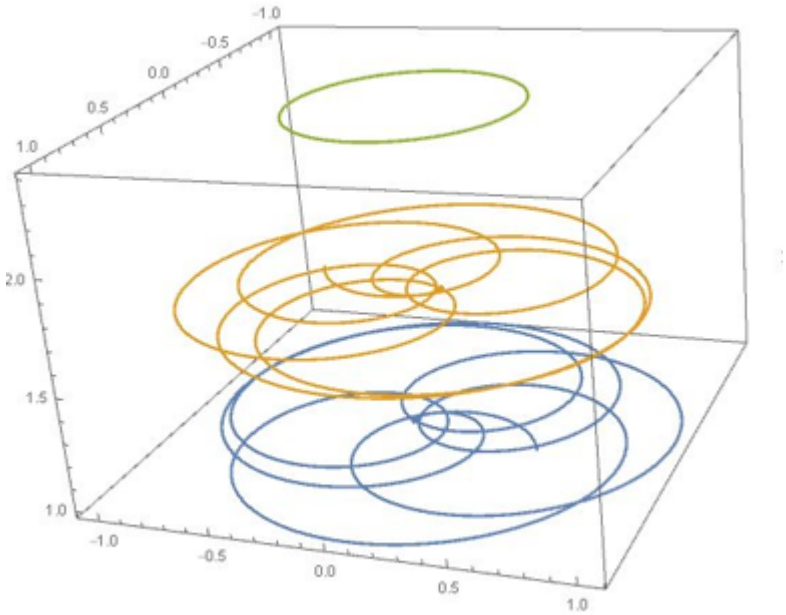

Figure 18: The result of the simulation of the stable which created flower trajectory

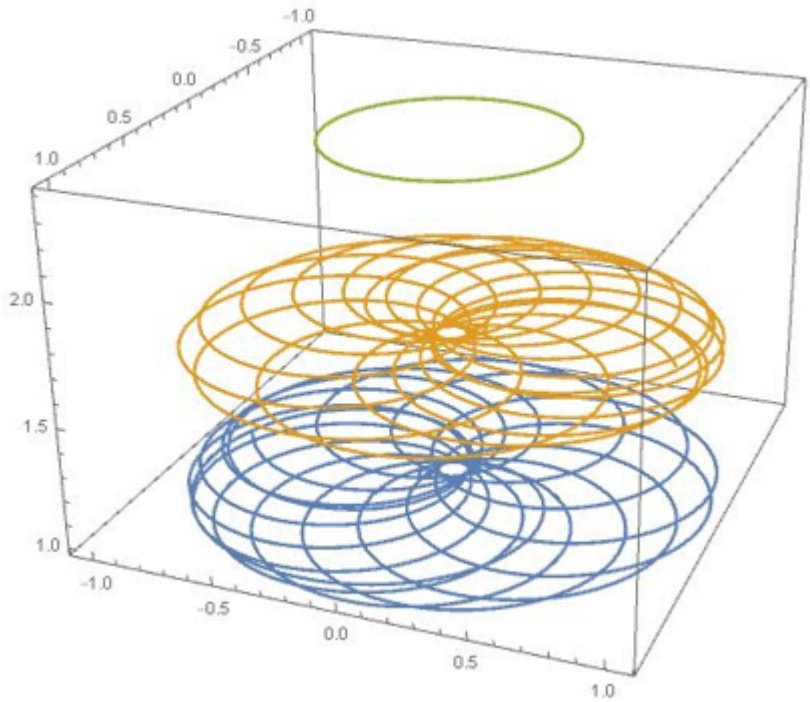

Figure 19: The result of the simulation of the stable which created flower trajectory

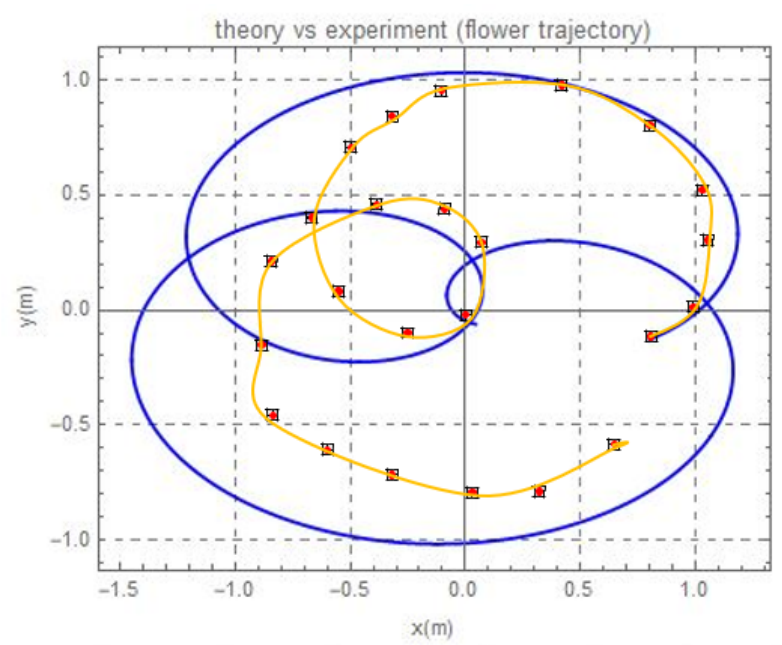

Figure 20: The correlation between theoretical and experimental results on flower trajectory

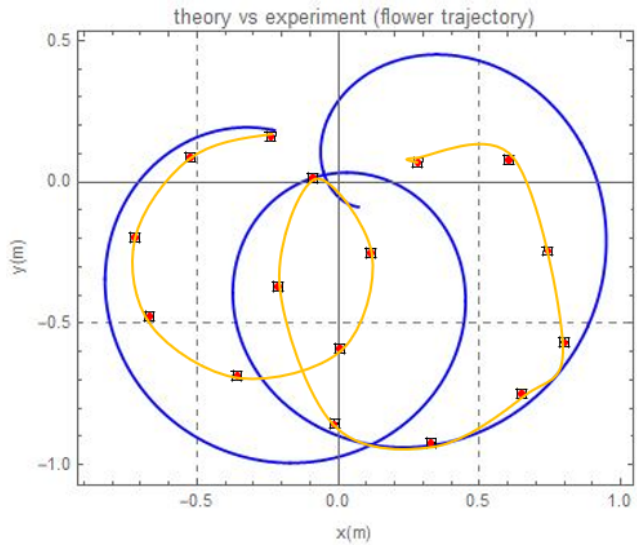

Figure 21: The correlation between theoretical and experimental results on flower trajectory

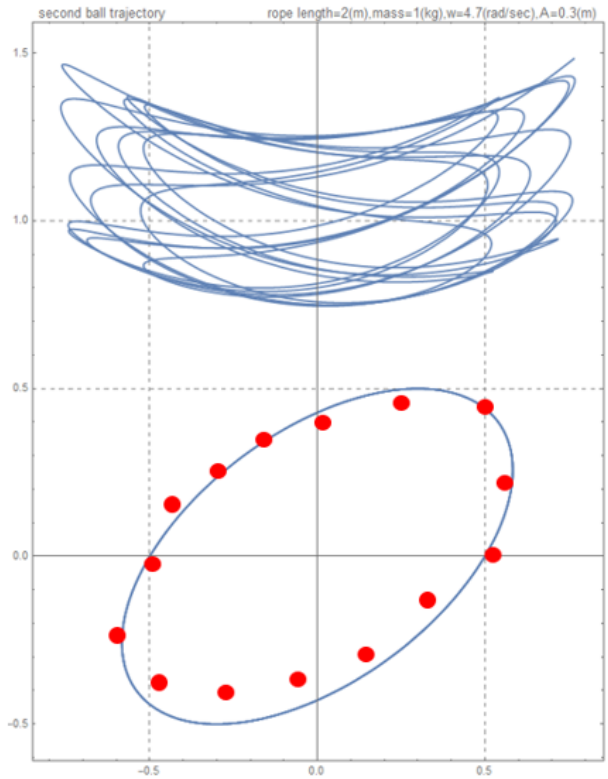

Figure 22: The correlation between theoretical points and experimental points on the chaotic motion of the second ball. Here masses of the ball equal 1kg, rope length =2m, w=4.7rad/s and A=0.3m

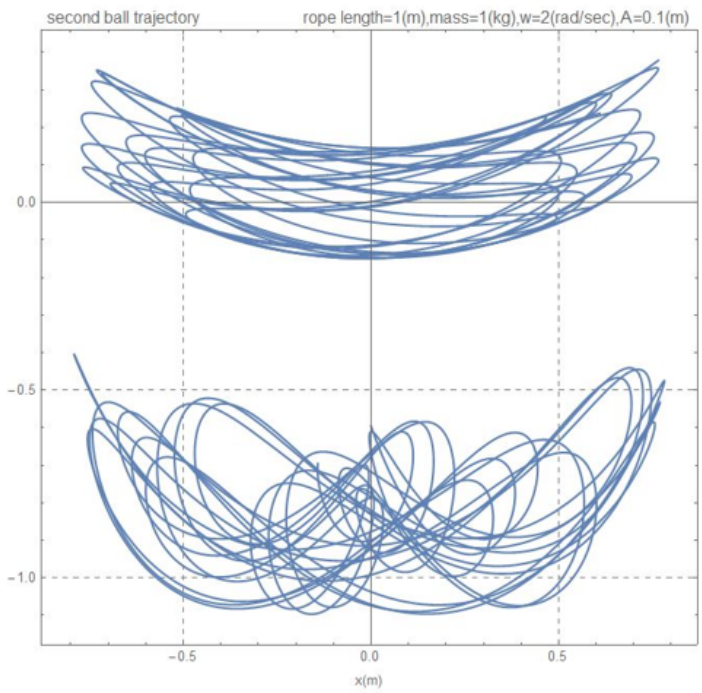

Figure 23: Simulation of chaotic movement of second ball in x y plane with initial conditions : mass=1kg, rope length=1m,w=2rad/s,A=0.1m

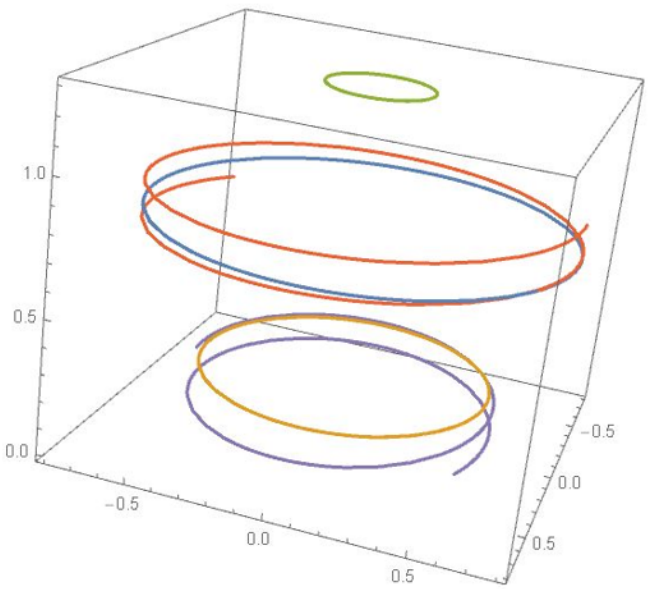

Figure 24: The correlation between theoretical and experimental trajectories in stable motion

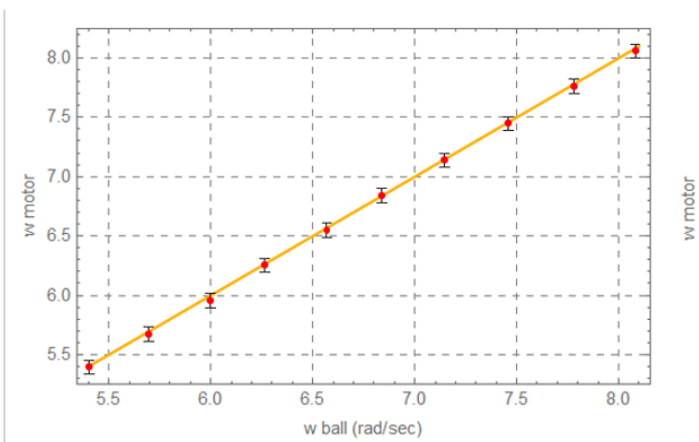

Figure 25: The ratio of the rising angular velocity of the motor and the angular velocity of the balls and the experimental points of the angular velocities

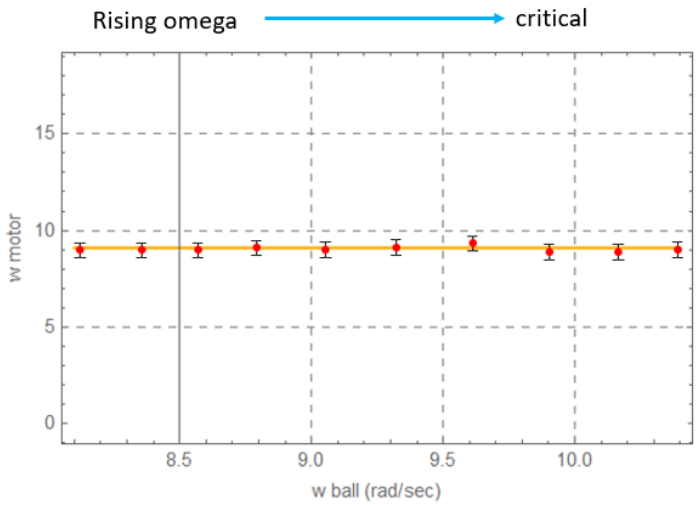

Figure 26: The ratio of the angular velocity of the motor and the angular velocity of the balls and the experimental points of the angular velocities

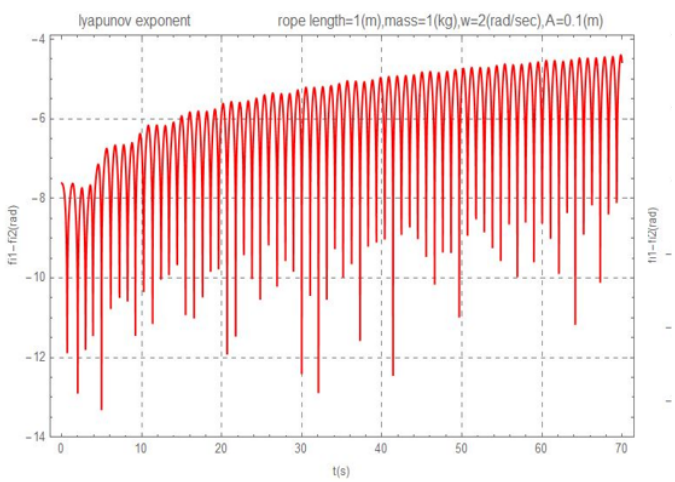

Figure 27: The Lyapunov exponent of the system on a long time

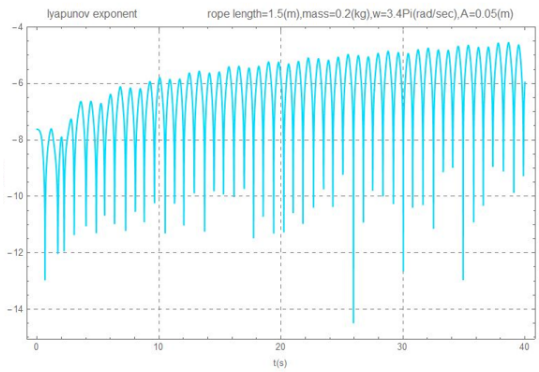

Figure 28: The Lyapunov exponent of the system on lower times

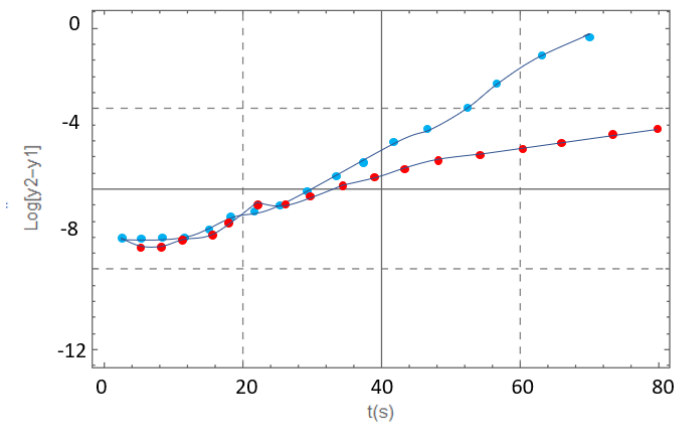

Figure 29: The correlation between theoretical and experimental points of Lyapunov exponent for the whole system

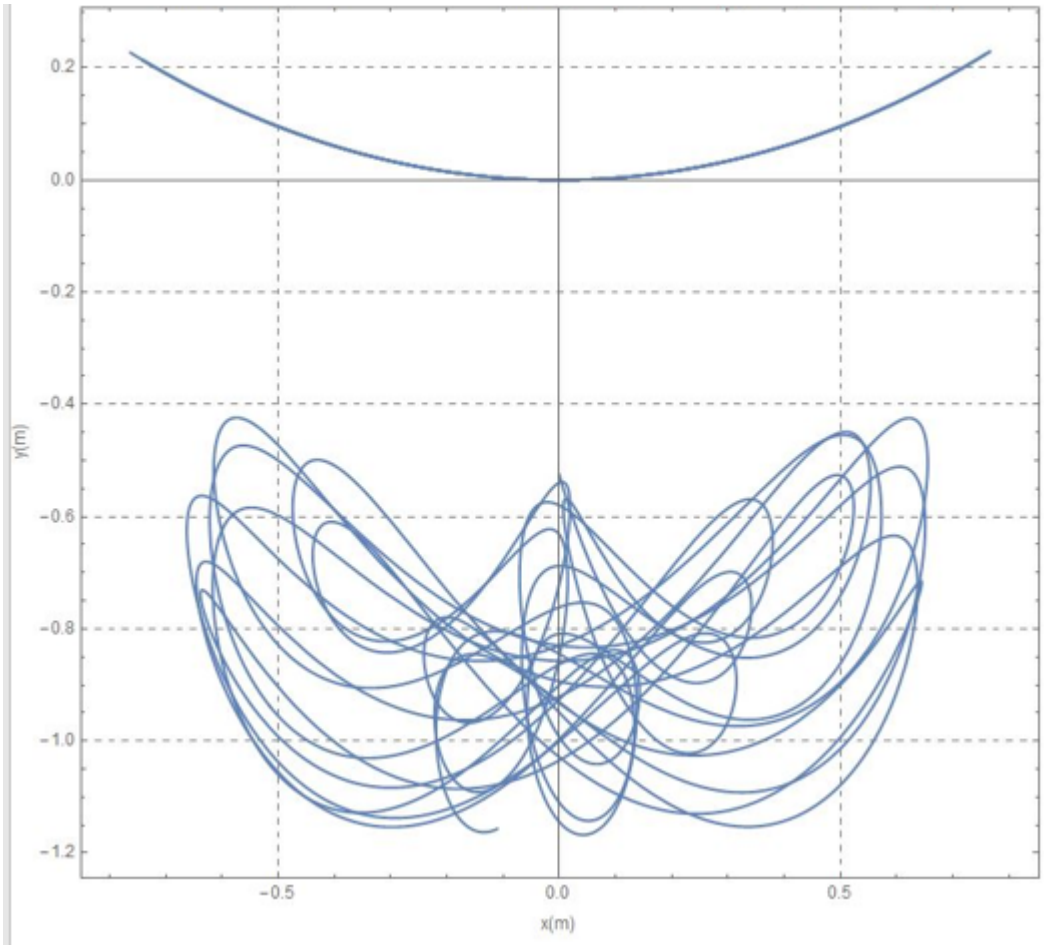

Figure 30: The trajectory of the first ball in chaotic movement

In Figure 17, it is noted that the balls describe a circular or more ellipsoidal trajectory at an angular velocity of less than 11 rad/s. Meanwhile, in Figure 18 and Figure 19, at angular velocities above 11 rad/s, the balls begin to describe a trajectory in the form of a flower. The first and second balls in Figure 30 and Figure 22 tend towards chaotic movements. Their drawings are quite similar. In Figure 27, the Lyapunov exponent initially holds at -7.70 for up

to 6–7 seconds; however, it later begins to grow throughout the chart up to -4.25. The same trend is visible in Figure 28.

Discussion

Based on the graphs, it can be concluded that the theory agrees with the experiment with little error. In Graph 25, it is noticeable how the points lie almost on a straight line, which means that the angular velocity of the end of the thread coincides with the angular velocity of the balls. One of the hypotheses was confirmed. In Graph 26, it is also noticeable that the experimental points fall neatly on the theoretical line. Another conclusion that was drawn from the experiment is that at high omegas, the system becomes critical and no longer describes circular paths, and at even larger ones, the upper ball begins to fall on the lower one and the system stops moving.

As mentioned previously and predicted by the theory, at high angular velocities, the centripetal force becomes less than the force of gravity and the ball falls onto the second ball. This was also confirmed experimentally.

Looking at Graph 24, it is also noticeable that the theoretical and experimental trajectories coincide in pattern, but do not coincide in height. In the future, the initial conditions will strongly influence the trajectory of movement.

In figure 22 it can be seen that on 4.7 rad / s the lower ball will have a stable trajectory and it can be compared with theoretical points as seen in the figure. As a result, the points are noticeable enough to converge

The charts themselves coincide in pattern in Figure 20 and Figure 21, but the error is sufficient. Considering that the movement here is already partially chaotic, the match can be considered sufficient. Another conclusion that can be made is that the initial conditions have the most influence, which is not surprising. Euler's method for solving differential equations is very dependent on the initial conditions. Therefore, both in theory and in experiments, everything depends on the initial conditions. Indirect factors may also affect the trajectory.

In Graph 27 and Graph 28, the Lyapunov exponent grows slowly and has negative values. This means that the points should converge, which is seen on the charts. However, the fact that the exponent grows indicates that the system becomes more chaotic over time, which is also observed in the trajectory graphs. At the very beginning, the exponent does not change. The only thing that can be said is that at the beginning, there are the factors caused by the ball's movement and other indirect factors.

In Graph 29, in the time from 0 to 40 seconds, the theoretical and experimental points of the Lyapunov exponent converge with small deviations, but already from 40 seconds, discrepancies occur. The only thing that can assume is that at large t the system becomes so chaotic that the theoretical values have large deviations from the experimental ones.

Conclusion

In this paper, chaotic and stable movements were considered. Later they were described by differential equations in 3 planes. Differential equations were solved using a python program. The results of the study showed that theory quite accurately coincided with the experiment. In some situations, the initial conditions influenced the course of the experiment, but these were not significant deviations. All hypotheses were confirmed and a new flower trajectory was revealed at w = 11.34 rad/s flower trajectory. The Lyapunov exponent was also calculated and compared with experimental data, from which it can be concluded that the theory for chaotic motion can accurately describe the system's behavior.

In the future, ít will be possible to describe all variants of the system using Lagrangian mechanics without dividing them into types of motion. It is also possible to study the conditions of motion at very high angular velocities and describe the motion during horizontal and other types of oscillatory movements.

In general, this kind of movement should be studied to better understand chaotic movements and, in general, the movements of various pendulums. This knowledge can help make the toys themselves better.

For references, footnotes and endnotes, click here.

Psychology

The Voices in My Head

Maha Sawhney

Maha Sawhney is a student in London currently studying A Levels in Biology, Chemistry and Maths. She is interested in studying medicine at university and enjoys learning about the brain.

Abstract

As I am writing this, I hear the words that I am typing through a voice in my head. Some people, however, do not hear these words at all and instead just type. For some people, having a very loud internal monologue can lead to schizophrenia or other mental health problems but for others, the internal monologue just remains as the voice in their head.

What is an Internal Monologue?

An internal monologue is also referred to as self talk, internal dialogue, or an inner voice,[1] and is often developed in childhood – which is called 'private speech'. Not everyone has an internal monologue, however everyone has internal thoughts. Those with an internal monologue have these thoughts vocalised internally[2]. When reading books, those with an internal monologue can hear the individual characters' voices talking and conversing with each other.

An internal monologue helps to strengthen memory as you are reciting everything in your head, whilst your brain is also being used actively to have conversations with yourself. In experiments carried out by Mark Scott at the University of British Columbia, results showed that the main feature of the brain that plays an essential role in our internal monologue is the signal *corollary discharge*[3]. This signal helps us distinguish between sensory stimuli produced by ourselves and those produced externally i.e., produced by someone else and helps our auditory system process speech. Corollary discharge also explains why our voice sounds different in our head than when we hear it in a recording.

The Effects of an Internal Monologue on Mental Health

Those with a loud internal monologue might not be able to control it, hence, resulting in mental health problems like schizophrenia. Schizophrenia is a serious mental health illness that affects how a person thinks, feels, and behaves[4]. The symptoms of schizophrenia can be grouped into three main categories: psychotic, negative, and cognitive. One of the main causes for the

psychotic symptoms is the internal monologue as the person affected will experience hallucinations, delusions, and thought disorder.

Auditory verbal hallucinations – the experience of hearing a voice without a speaker present – are also strongly associated with a diagnosis of schizophrenia[5]. It is thought that auditory verbal hallucinations are the result of one's internal monologue that is wrongly assumed to be from an external source[6]. This is due to the fact that these hallucinations are not self-monitored, so those experiencing it are unaware that the voices they are hearing are their own[7]. In order to overcome this, research has been done to see if any antipsychotic drugs can help those suffering from these hallucinations, however, due to side effects such as weight gain, cognitive behavioural therapy is normally used. This helps the patient to change the tone of the hallucination so it can be more easily managed[8].

For the majority of people, their internal monologue can be more negative than positive, which can lead to a negative outlook of the world. This pessimistic self-talk is associated with mental health issues such as low self-esteem, depression, anxiety, and burnout[9]. To reduce this effect, one should try to replace these negative thoughts with positive ones. Though this will take time, it is essential to ensure that one's outlook is positive. There are many ways to achieve this; through meditation, exercise, or following the chimp paradox model. The model states that our negative thoughts are 'gremlins' and in order to replace them, every time we experience a 'gremlin thought' we should try and replace them with the positive version of this. Overtime, one will experience a reduced number of 'gremlin thoughts' and more positive thoughts; this will then make the internal monologue more optimistic.

Having an internal monologue is completely natural and can be both good and bad. It can help us with our memory and helps to keep the brain active. Some people might have a louder internal monologue than others, and some might not even have an internal monologue. If your monologue becomes more negative, make sure to exercise, and try to replace your thoughts with more positive ones.

For references, footnotes and endnotes, click here.

Psychology

Bias in Psychology and its Consequences

Olivia Njideka Obi-Washington, *United States*

Olivia is currently a Senior at Mills E. Godwin High School with a passion for debate, political science, and social psychology.

As people who exist in today's modern world, our moral compass is equally as modernized. We can all agree that an individual's mental, psychological, emotional, and cognitive health should be valued no matter their race, ethnic background, or identity. Regrettably, this idea is not synonymous with the practices that have been seen in the field of psychology over the years. Even now, bias in psychology rears its ugly head towards the marginalized groups that require its help the most.

One exceptionally pertinent and infamous example of ethnic/racial bias in the history of psychology can be seen in South Korea. In the very early 1900's, the nation of Korea was annexed (or taken over and put into subordination by another larger nation). As they were systematically stripped of their national, cultural, and ethnic identity, there was one change with specific relation to this topic: How their approach to psychology changed. Before the annexation, Korean culture dictated that afflictions of the mind be treated through traditional medicine and Shamanism. There was no shame or fear involved and it was approached with open communication, trust, and a relative lack of judgement. The Annexation of 1910 changed these attitudes very quickly. The ethnically significant practices of clinics and Shamans were done away with completely and were instead replaced with government sponsored mental facilities. It was no longer a place that was meant to heal, but was now a place meant to conceal. Anyone and everyone that was suspected of exhibiting undesirable traits or mental illnesses were to be reported immediately and sent to one of these mental facilities where they would be entirely isolated from the outside world and kept in detention indefinitely. Korea would later be free from annexation by the late 1940's, but the damage had already been done. Even though it has been well over a century since they were annexed, South Korea's negative attitude towards psychologists and mental health has remained largely the same. The national government devotes practically no attention to it, as it has

documented a decaying amount of funds put towards mental health care since 2005. Personal attitudes are equally as bleak, with a local study finding that nearly 89% of South Koreans had experienced a mental health disorder at some point in their lives, but only 7% of people sought help for one.

This unfortunate trend of generational trauma and historical skepticism towards psychologists and their profession has been reflected across marginalized groups in the United States as well. For a very long time in the U.S., mental health was considered a luxury that people of color were not allowed access to. Racial and ethnic prejudice was rampant in the psychological and medical health communities. Despite society making progress since those days, minorities in America are still feeling the effects. When measuring Black, Hispanic, and Asian-American adolescents who received treatment for mental health disorders, studies showed that they were all less likely to receive medical treatment, in-patient mental health treatment, and prescription medication than white adolescents.

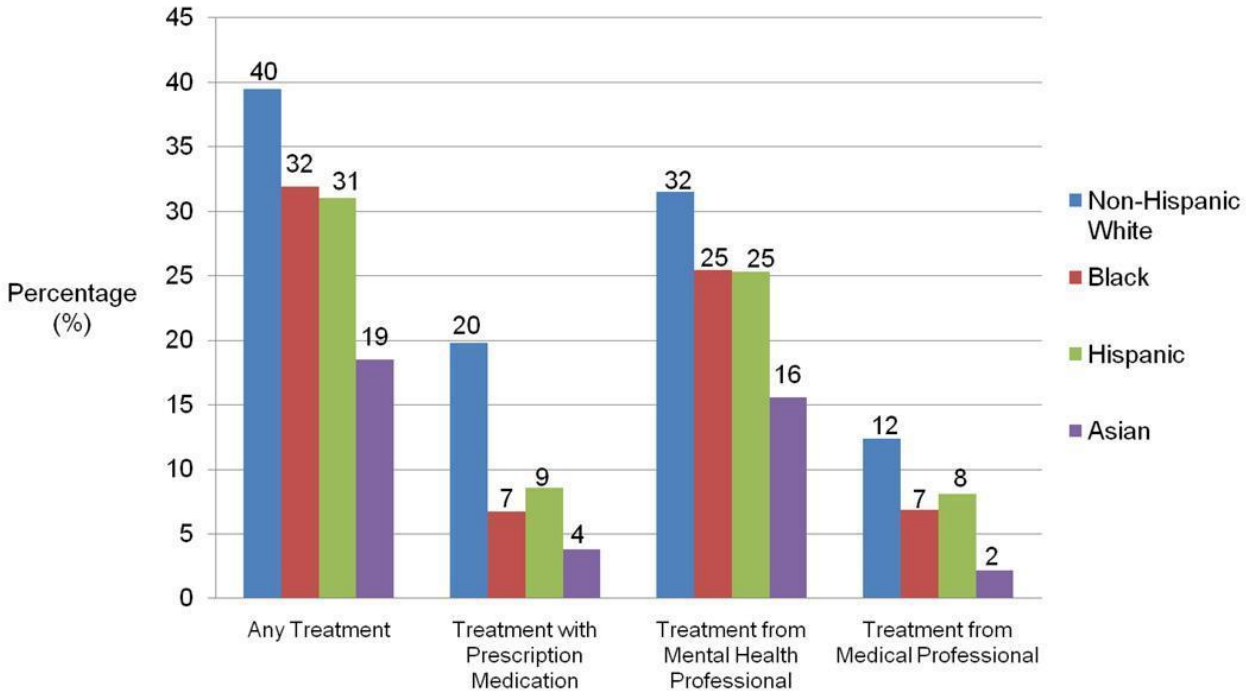

Figure 1: Adjusted percentage of U.S. adolescents who received treatment for major disorders by race/ethnicity. Note: N=7,618. Results from multivariate probit models adjusting for age.

These high levels of suspicion and avoidance are a cognitive defense technique that is meant to be a protective measure against mental harm. However, because there are so few individuals from marginalized groups going to psychologists, the psychologists in the field who possess these biases (whether they are consciously or unconsciously exhibiting them) do not have an adequate or extensive amount of experience with understanding the mental health challenges that these marginalized individuals face. This total lack of experience leads to further ignorance and,

inevitably, this ignorance leads to many, many, many misdiagnoses. Take African-Americans and Hispanic-Americans, for example: Black and Hispanic teens are around 50% more likely to experience eating disorders, black women are over 2x more likely to develop postpartum depression, black men are nearly 30% more likely to be falsely labeled with schizophrenia, black and Hispanic children are up to 70% more likely to be ignored when showing signs of ADHD, etc. Or take Asian-Americans as another example: Asian-American adults are 17% more likely to experience a mental disorder or crises in their lifetime, more likely to experience depression, and more likely to have suicidal ideation. And yet, all of these groups are either underdiagnosed or misdiagnosed completely, in comparison to their European or caucasian counterparts.

This damaging routine is known as the Cycle of Mistrust. Intrinsic bias in psychology has led to marginalized individuals and people of color being mistreated in clinical care. This leads to those maltreated groups being conditioned to avoid psychologists and psychology in general. This leads to clinical malpractice not being able to evolve or progress to properly help these groups, which leads to further malpractice, which leads to a further lack of trust. It is a self-fulfilling prophecy that only serves to perpetuate neglect towards the wellbeing of society's most vulnerable populations.

For references, footnotes and endnotes, click here.

Biology

Using Nighttime Light Data to Estimate the Impact of COVID-19 Vaccinations in the United States

Basri K. Alhan and Nur Pakir, *Istanbul and Turkey*

Basri Kerem Alhan is an 18 year old Turkish high school graduate and an aspiring researcher. He plans to study in multidisciplinary subjects and is interested in statistics, physics, mathematics, and economics.

Nur Pakir, an 18 year old Turkish high school graduate, is an aspiring artist who is also interested in statistics, economics, artificial intelligence, and psychology.

Abstract

This paper aims to detect the social impact of the COVID-19 vaccines in the United States. We presume that COVID-19 vaccines have reduced the overuse of lights in domestic settings caused by lockdown procedures. In particular, the changes that occurred in monthly nightlights data in the United States. Nighttime Lights has been an established proxy for measuring economic activity. This increasing rate of people vaccinating will lead people to leave their houses; hence, individual light usage will decrease. We applied least squares regression between COVID-19 total vaccination numbers from all vaccines that the U.S. approved and the sum of nightlight intensity. Unfortunately, we did not find statistically significant results as the nightlight data from February 2021 was most likely distorted. Nonetheless, we believe that this research will pave the way to more remarkable researches about tracking the impact of COVID-19 vaccinations with nighttime lights data.

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1. Introduction

Causing the death of millions, economic losses, social, psychological, and many more problems, COVID-19 has changed the science world's focus to the development of vaccines. In the United States, the FDA (U.S. Food and Drug Administration) issued the first emergency use authorization (EUA) of a vaccine allowing Pfizer-BioNTech COVID-19 vaccine on December 11, 2020. Following this, the U.S. authorized Moderna, Johnson & Johnson's Janssen vaccines. Since then, the number of total vaccinations [1] has been accelerating rapidly in all states. Consequently, social life has been returning to its old form once again; people who got vaccinated at least one dose started to feel less afraid to socialize.

We assume that when the virus spread over the globe and new regulations causing people to isolate themselves came into force, light usage in personal spaces increased while it decreased in common areas such as workplaces. To test our hypothesis, we analyzed monthly nighttime lights data and monthly total COVID-19 vaccination counts.

Nightlight data has been widely used over the last decade as a proxy to measure economic activity and many others. In this case, we mainly focused on researches that use nightlights as a proxy of economic activity, starting from Henderson *et al*. (2012) , [2] who found that nighttime light intensity's growth in a country can be used as a proxy to show long-term GDP growth of that country. Additionally, Pinkovskiy and Sala-i Martin *et al*. (2016) constructed a new method to measure real GDP per capita using a combination of nighttime lights data and survey-based GDP measures. Since then, nighttime lights data has had its place in the economics literature, and the usage of data has been improving; for instance, an IMF (International Monetary Fund) working paper by Yingyao Hu and Jiaxiong Yao (see WP/19/77) used similar ideas with Henderson *et al.* (2012) and Pinkovskiy and Sala-i Martin et al. (2016) with two main differences. The first is that the optimal linear combination relies on estimates of the measurement error distributions in nighttime lights and national accounts GDP data. The second difference is that the optimal weights on nighttime light-predicted GDP differ for each country in each year.

[1] Data collected from U.S. Food and Drug Administration and Centers for Disease Control and Prevention.

[2] Henderson et al. (2012) aimed to show how current GDP calculating methods could not estimate the actual results in developing countries fully and that their calculated GDP results were inaccurate with the use of nighttime light data as a proxy to measure economic activity.

Most previous researchers who used nighttime lights to proxy economic activities relied on data from satellite sensors of the now inoperative U.S. government Defense Meteorological Satellite Program- Operational Linescan System (DMSP-OLS). Although they have several disadvantages that

hinder how accurate they proxy economic activity -such as the sensors being unable to detect high nighttime light intensity caused by sensor saturation - (Gibson *et al.*,2021 and Roberts *et al*. 2021), [3] DMSP-OLS data have a long annual time series spanning over 21 years (1992-2013). In addition, on the report of Gibson's "Better Night Lights Data, For Longer," one of the most significant disadvantages these data have is the "over-glow" phenomenon: The light emitted from a point on earth is recorded in DMSP-OLS data as covered outside of that area, usually excessively remote, which is a problem for subnational analysis.

Alternatively, we used nighttime lights data from the VIIRS satellite sensor, operated by the National Aeronautics and Space Administration (NASA) - National Oceanic and Atmospheric Administration (NOAA) Joint Polar Satellite System (JPSS), to correlate with COVID-19 vaccination data. There are several crucial differences between VIIRS and DMSP-OLS data. Unlike DMSP-OLS, which has no low-light imaging band calibration, VIIRS uses solar diffusion to calibrate daytime DNB data. Moreover, the "over-glow" phenomenon is much more minor, and in contrast, they can detect nightlights with much higher intensity because saturation does not affect data.[4] Additionally, unlike DMSP-OLS data available at an annual frequency, VIIRS satellite images are produced monthly, which is critical for our intent to show the impacts of monthly vaccination rates. VIIRS satellite images have been available since 2012. Due to the discontinuation of DMSP-OLS data in 2013, some researchers used DMSP-OLS and VIIRS; for instance, Jeet Agnihotri and Subhankar Mishra *et al*. (2021) used both satellite data to analyze India's economic growth in a much more historically detailed way.

In truth, we intended to base our research on measuring GDP by nightlights data and correlating our findings with COVID-19 vaccination rates similar to how Mark Roberts *et al.* examined the economic impact of the COVID-19 crisis with the proxy of nightlight data. However, we did not use this method because of two reasons. First, the estimation of GDP with nightlights as a proxy has been well-established over the past by many researchers. Second, we did not have sufficient information to develop a statistical framework. Previous researchers based their statistical framework on DMSP-OLS data, and we could not process statistical frameworks based on VIIRS data with our current informational resources.

[3] DMSP-OLS data measured the nighttime light intensity on a digital number (DN) scale with a range of 0-63.

[4] VIIRS satellite data measures light luminosity in nanoWatts/cm^2/sr units.

The structure of this paper is as follows: Section 2 describes the collection of data in VIIRS satellite sensors and COVID-19 total vaccination numbers, possible errors in our results in consequence of cloud coverage, processing the monthly data, and processing annual nightlight data before COVID-19 to strengthen the ideas around the use of nightlight data as a proxy to track human activity. Section 3 describes the correlation between the sum of lights (SOL) and total COVID-19 vaccinations monthly and OLS regression results for the correlation. Finally, Section 4 concludes by

discussing the results and reliability of data to understand the impact of COVID-19 vaccinations on nightlight data.

2. Data

2.1. Data Collection of Nighttime Lights

As discussed above, we collected the nighttime lights (NTL) data from the VIIRS satellite sensor that incorporates the Soumi-NPP satellite. Specifically, we use the VIIRS nightlights' monthly composites produced by the Earth Observation Group (EOG) at the Colorado School of Mines . The Soumi-NPP satellite scans the Earth twice [5] each day, crossing the equator around 1:30 and 13:30. Each tile is a set of images [6] *n anoWatts/cm*^{2} */sr* containing average DNB radiance values with units in . We use annual composites from 2012 to 2020 and monthly composites from 2021, where 2012 is the year the first composite was publicly available since the launch of the Suomi-NPP satellite in 2011 . These composites make our estimate of vaccination and nightlight [7] data correlation more accurate since it contains cloud-free average radiance values and removes the outliers caused by fires, aurora borealis, and other ephemeral lights. We selected the V1 monthly non-tiled "vcmslcfg" average data to calculate the sum of total NTL intensity (SOL) for 2021 monthly nighttime lights data and average V2 annual data from 2012 to 2020 to view the accuracy of nighttime lights and tangible example of comparison between DMSP-OLS and VIIRS.

Table 1 gives some sense of the data, describing the difference between urban and non-urban areas, and strengthening the reason behind our decision to use NTL as a proxy. We scaled the pixel values ranging from 0 to more than 50 and divided them into seven classes as seen in the table to visualize our results since VIIRS satellite data give results with non-integer values.

The group is the same as that which produced the DMSP-OLS annual composite nighttime lights [5] data sets and was formerly based at NOAA.

The composites cover the globe from 75 N latitude to 65 S. [6]

Annual and monthly VIIRS composites are available by EOG on their website (https:// [7] eogdata.mines.edu/products/vnl/). We obtained composites by registering to EOG website.

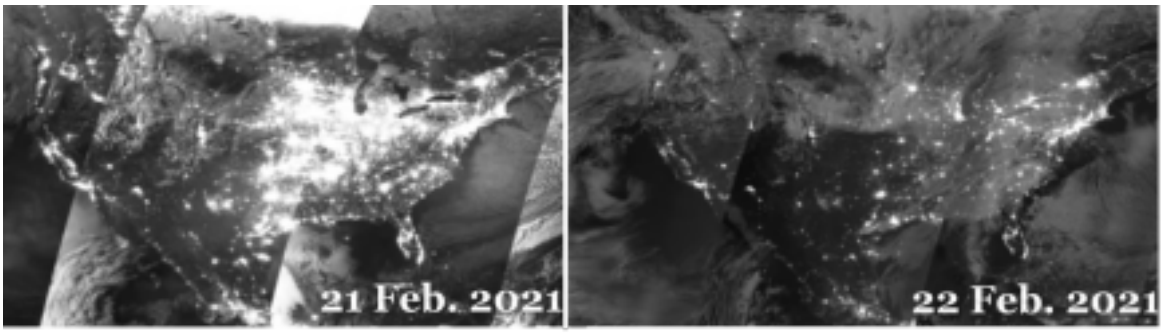
Table 1—Night Light Data for United States, 2012-2020

DN	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	1.71%	2.16%	2.63%	2.33%	2%	3.17%	3.33%	3.07%	3.37%
1-2	21.85%	20.67%	18.87%	19.41%	20.11%	18.04%	17.3%	17.21%	16.57%
3-5	22.06%	22.05%	21.58%	21.74%	21.61%	22.1%	22.03%	21.85%	22.18%
6-10	18.29%	18.3%	17.45%	17.77%	17.79%	18.02%	18.19%	18.37%	18.76%
11-20	17.40%	17.47%	16.86%	17.17%	17.26%	17.33%	17.54%	17.73%	17.96%
21-50	15.05%	15.51%	16.99%	16.55%	16.45%	16.45%	16.64%	16.68%	16.56%
>50	3.64%	3.86%	5.66%	5.03%	4.77%	4.9%	4.97%	5.09%	4.6%

There are exceptionally few pixels among the years in Table 1 with the digital number 0. The most commonly observed range of digital numbers is from 3-5. When we compared the DMSP-OLS values from Henderson *et al. (2012)* and VIIRS values, we found more values in the range 1-2 and much fewer 0-pixel values. The difference is a result of VIIRS having a wide range of units and processing non-integer values. Additionally, annual nightlight data from Table-1 shows how human activity has accelerated over the years.

In monthly composites of VIIRS satellite data, there is a clear distinction between February 2021 and other months in data and visual representation. Figure 1[8] shows an extreme decrease from February 21, 2021, to February 22, 2021, in images collected from NASA's Suomi-NPP satellite images. Not only that, images collected from all variations of satellite data (with cloud, cloud-free, tiled, and non-tiled) show nearly the same level of extreme decrease.

Figure 1—NASA Suomi-NPP satellite images



This rapid decrease in nightlight data directly affects the outcome of this research (see

Figure 1 Suomi-NPP satellite data are collected from https://worldview.earthdata.nasa.gov. [8]

We focused our research on the first four months of 2021 as only The EOG's first four months of 2021 data are currently accessible. Moreover, The VIIRS data are publicly available at a monthly frequency with a short time lag. We did not use VIIRS data from December 2020 because, as discussed above, COVID-19 vaccines have been available since December 11, 2020.

Figure 2—Nightlight images of U.S. in first four months of 2021

Figure 2 gives a visual promoter to understand the changes in the COVID-19 vaccination period between January, February, March, and April 2021; there are observable changes in VIIRS data for all four months. (For raster methods, see Section 3.)

2.1. Data Collection of COVID-19 Vaccinations in the U.S

The data we collected to represent 2021 COVID-19 vaccination rates are total vaccination numbers instead of the second dose of vaccination numbers as using second dose vaccination numbers could be biased to show socio-human activity. This idea stems from our belief that the number of people going to social settings this year could alter based on the dosage of vaccinations, and additionally the government bases its regulations on total vaccination rates. We collected data from Our World in Data . [9] We subtracted every new month's data from the old one to find monthly changes in numbers with newly found data.

[9] Vaccination data can be found in https://ourworldindata.org/covid-vaccinations?country=USA and the data's open source codes in https://github.com/owid/covid-19-data/blob/master/public/data/vaccinations/README.md.

3. Methods

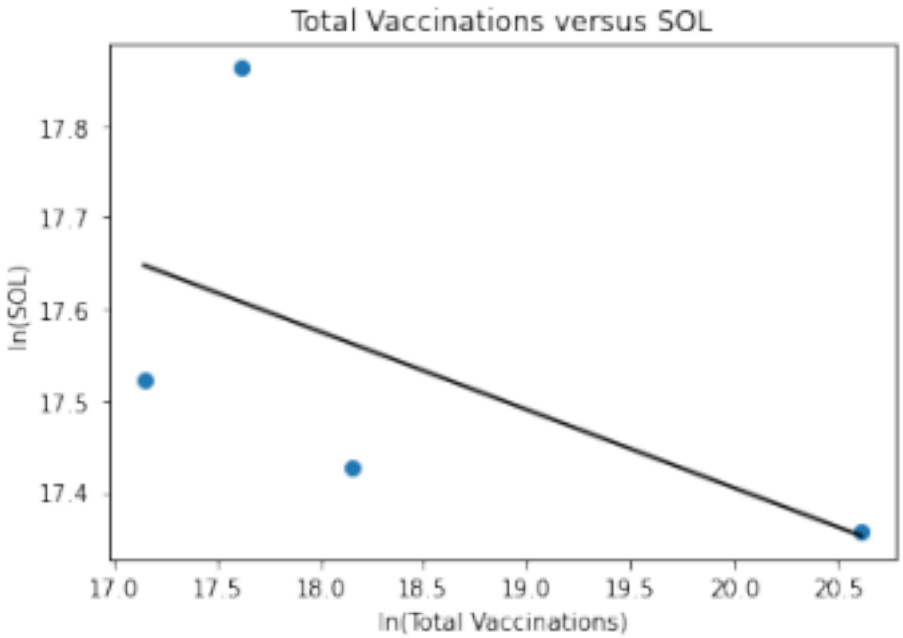
After obtaining monthly nightlight composites from EOG, we first clipped the raster by mask layer of the United States nightlight data from its borders to differentiate the U.S. from other countries. Secondly, we converted raster to vector (polygonizing) to find the digital pixel numbers in csv. files. We did this method to all [10] v1 monthly EOG composites formats to confirm that our values were correctly defined. Finally, we summed up our monthly digital numbers and found monthly SOL values to correlate with monthly vaccination numbers.

We applied least squares regression to see the correlation between monthly SOL and monthly total vaccination numbers. We assigned monthly total vaccination numbers as an independent variable and monthly NTL data as a dependent variable. After applying logarithmic regression to our data, we obtained OLS Regression Results to seize upon any information from our logarithmic regression results. Finally, we graphed a scatterplot and used least square method to graph a line of best fit

4. Results

In Figure 3, as discussed above, the independent variable is monthly total vaccination data, while the dependent variable is monthly SOL. As a result, the scatterplot of the logarithmic regression shown in Figure 3 displays a negative correlation between monthly total COVID-19 vaccination numbers and monthly SOL numbers.

Figure 3— Least Squares Regression Results



All raw EOG composites are processed in QGIS. [10]

In Figure 3, February 2021, nightlight data is an outlier in the scatterplot. As discussed above (see Section 2.1), February directly affects the correlation. We observed a negative correlation from Figure 3 and Figure 4.

Figure 4

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.344
Model:                            OLS   Adj. R-squared:                  0.016
Method:                 Least Squares   F-statistic:                     1.048
Date:                Sun, 19 Sep 2021   Prob (F-statistic):              0.414
Time:                        12:53:04   Log-Likelihood:                 1.7246
No. Observations:                   4   AIC:                            0.5508
Df Residuals:                       2   BIC:                           -0.6766
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         19.1073      1.532     12.470      0.006      12.515      25.700
x1            -0.0851      0.083     -1.024      0.414      -0.443       0.273
==============================================================================
Omnibus:                          nan   Durbin-Watson:                   3.192
Prob(Omnibus):                    nan   Jarque-Bera (JB):                0.590
Skew:                           0.786   Prob(JB):                        0.745
Kurtosis:                       1.968   Cond. No.                         255.
==============================================================================
```

As seen in Figure 4, our R-squared value from least squares regression is 0.344, which means a weak result for our research. We assume that a weak correlation may have been caused by February. Other months are moderately good for the line of the best fit data. On the other hand, the r-value we estimated is -0.58, which is a substantial correlation value. However, since the sample size is too small, we cannot conclude that our results are statistically significant.

5. Conclusion

This paper has explored the probability that COVID-19 vaccination rates might correlate with VIIRS nighttime light data. Even though our results were not statistically significant, we found that with enough sample size, we can still track medical activity with nighttime lights in the future. Furthermore, our analysis can potentially be extended in the future. Finally, without any light distortion recorded, like in February, in the sample, we believe that some correlation can still be found between vaccination rates and nighttime lights data.

For references, footnotes and endnotes, click here.

Chemistry

EVALUATION OF LEVELS OF PERFLUOROOCTANOIC ACID AND PERFLUOROOCTANE SULFONIC ACID IN THE RIVERS OF CHENNAI, TAMILNADU

SANCHITA SENDIL, *India*

Sanchita Sendil, currently a 12th grade student is passionate towards green chemistry principles and intends to pursue chemical engineering at university.

TABLE OF CONTENTS

EVALUATION OF LEVELS OF PERFLUOROOCTANOIC ACID AND PERFLUOROOCTANE SULFONIC ACID IN THE RIVERS OF CHENNAI, TAMILNADU 1

TABLE OF CONTENTS 2

ABSTRACT 2

RESEARCH QUESTIONS/HYPOTHESIS 3

LITERATURE REVIEW 4

ANALYSIS OF DATA 7

3.1 Map showing sampling sites in Chennai, TamilNadu. 7

3.2 Concentrations of PFOA at different rivers in Chennai, TamilNadu 9

3.3 Froth formation in Noyyal River, Chennai, TamilNadu 10

3.4 Concentrations of Total PFASs, PFCAs and PFCs in Chennai 11

3.5 Concentrations of PFOA and PFOS in water samples from tributaries of the Noyyal, Cauvery River and other lakes in and around Chennai, TamilNadu. 12

DISCUSSION 14

CONCLUSIONS 15

ACKNOWLEDGMENTS 16

BIBLIOGRAPHY 17

ABSTRACT

Perfluorooctanoic acid (PFOA) and Perfluorooctane sulfonic acid (PFOS) are bio persistent and bioaccumulative chemicals that are found in the blood of people worldwide, suggesting that exposure to these chemicals is widespread. PFOA and PFOS have been found in the flesh of marine animals, soil, air and water. The contamination of waterbodies with PFOA and PFOS as well as the indirect contamination of soil and groundwater is a major source for human exposure. Contamination of rivers with PFOA and PFOS is largely a result of improper disposal of wastewater and effluents from manufacturing facilities in close proximity to the rivers. It has been found that the levels of PFOA and PFOS in rivers vary directly with the number of manufacturing and industrial sites located nearby the river. The highest concentration of PFOA was identified at Noyyal River, possibly due to the effluent waste discharged by nearby manufacturing facilities and industries. However, the levels of PFOA and PFOS in the rivers were identified to be well below the permissible limit of PFOA and PFOA (400 ng/L and 200 ng/L respectively). This paper aims to assess the levels of the PFOA and PFOS in the rivers of Chennai, TamilNadu and highlight the possible sources of contamination.

RESEARCH QUESTIONS/HYPOTHESIS

1. How have the rivers of Chennai been contaminated with PFOA and PFOS?
2. How do the levels of PFOA and PFOS in rivers vary with the presence of manufacturing facilities nearby?

The need of the study:

This study aims to investigate the causes of PFOA and PFOS contamination in Chennai and evaluate the role of manufacturing and industrial sites that could have possibly led to higher levels of PFOA and PFOS contamination. The presence of manufacturing and industrial sites could lead to an increase in PFOA and PFOS levels in the rivers due to improper wastewater treatment and disposal of effluents into the river.

LITERATURE REVIEW

In 1938, a scientist from DuPont named Roy J. Plunkett accidentally invented Teflon when he was working with gases related to refrigerants. Years later in 1951, DuPont began manufacturing Teflon with the aid of a chemical additive known as Perfluorooctanoic acid (1). Perfluorooctanoic acid (PFOA) known colloquially as C8, is a chemical additive used in the manufacturing process of Teflon. PFOA is used to smooth out lumps and provide products such as pans with oil and water repellent properties. The problems associated with PFOA began to gain publicity when a group of farmers living close to the manufacturing facility of PFOA suspected a hazard with the emissions and waste produced from the facility. The cattle of the farmers had all died after drinking water from a creek close to the DuPont landfill; however, the concern was dismissed and the farmers were told their cattle had died because they simply did not take proper care of them(1). Today, exposure of PFOA is widespread and studies show that the general population and wildlife have PFOA in their blood.

People have been exposed to PFOA through direct and indirect means without their knowledge and as a result their blood is forever contaminated with PFOA and this poses an endocrine, immunological and carcinogenic threat. Unlike viruses and bacteria which can be eliminated from the system through medication, PFOA persists in the human system and is resistant to degradation (2). Further, PFOA present in the human body may lead to birth defects and delayed development. A documentary titled 'The Devil We Know' explores the ethical debate regarding who society should hold accountable for the widespread contamination of blood and the incidence of adverse health outcomes endured by individuals. Buck Bailey, one of the guests on the documentary, was born with severe face deformities due to the high level of PFOA in his mother's blood. Furthermore, Buck Bailey was told there is a high possibility his children may be born with face deformities due to the high levels of PFOA in his blood.

SOURCES OF PFOA CONTAMINATION

PFOA has been found in tap and surface water in several countries such as China, India and Japan. In addition, it has been detected globally in the tissues of marine animals and birds. Studies that aim to evaluate the level of PFOA exposure analysed serum - PFOA concentration and have found PFOA in the blood samples of the general human population indicating that the spread of PFOA is widespread. Some of the major sources of PFOA contamination are as follows :

1. WATER

   The sources of PFOA contamination in surface and groundwater include release from manufacturing facilities, wastewater treatment plants, industrial and municipal waste sites and consumer products such as disposal of water repellent fabrics. The pKa of PFOA indicates that when in contact with water, the substances will exist as conjugate bases (anions) and may be transported to remote locations through oceanic advention. Furthermore, PFOA may be transported in the form of marine aerosols as surfactants tend

to accumulate in upper sea layers and water surfaces (3). In a number of cities in the United States, PFOA has been found in surface water and sediment downstream of manufacturing plants, as well as wastewater effluent, sewage sludge, and landfill runoff (4).
In the case of DuPont and 3M the principal source of PFOA contamination was wastewater discharge containing PFOA effluents. PFOA is mobile and easily leaches into groundwater. In a 2018 study in Varanasi, PFAS, medicines, and pesticides were found in water aquifers deeper than 100 metres. PFOS levels ranged from 0.1 to 33 parts per trillion, exceeding the PFOA and PFOS drinking water health advisory guideline of 20 parts per trillion (5).

2. AIR

Studies suggest that PFOA is adsorbed by particles in the air since it is not found as a vapour, furthermore PFOA will react with atmospheric particles and form PFOA anions. Long range transport of PFOA is due to the biodegradation and photooxidation of a host of precursors of perfluorinated chemicals such as fluorotelomer alcohols and perfluoroalkyl sulfonamides. Degradation and photooxidation of these precursors results in the formation of PFOA and PFOS as the final product (6). Atmospheric transport of these precursors followed by photooxidation results in contamination in remote locations.

PFOA values ranged from 10 to 75,900 pg/m3 in high volume air samples collected at numerous monitoring stations near the Washington Works complex d between August and October 2005 (4). PFOA has also been detected in indoor air which could possibly indicate PFOA release from consumer products such as carpets and textiles. The concentration of PFOA in indoor air is comparatively higher than that of outdoor air (2). Additionally, PFOA may also be released from overheating of nonstick cookware coated with teflon; concentrations of PFOA emitted increased with an increase in temperature. This could be another source for the presence of PFOA in indoor air. PFOA can be transported long distances and has been detected in low concentrations in places as remote as the Arctic(4).

In Chennai, PFAS levels in particle air pollution were in the 2.5–10 um range, with a PM2.5/PM10 ratio of 0.38. In the samples, PFOA was the most prevalent component (5).

3. SOIL

Koc values indicate the mobility of a substance in soil; Koc values of PFOA indicate that it is mobile in soil, it remains in solution and migrates into groundwater (2). Alternative sources of PFOA contamination in soil include emissions of PFOA followed by atmospheric deposition and leaching. High concentrations of PFOA have been detected in soil near manufacturing and disposal sites. Concentrations of PFOA near airports and military bases were found to be quite high due to the use of aqueous film forming foams (AFFF) used to combat liquid fires such as fuel fires. Measured concentrations of PFOA in surface soils range from 8.0 ng/g to 287 ng/g (4). The concentration of PFOA in the soil was found to increase with depth providing evidence of the mobility and spread into groundwater. (7)

ANALYSIS OF DATA

3.1 Map showing sampling sites in Chennai, TamilNadu.

Figure 3.1 provides a visual representation of the locations of sampling. From the figure the presence of manufacturing and industrial sites can be analysed.

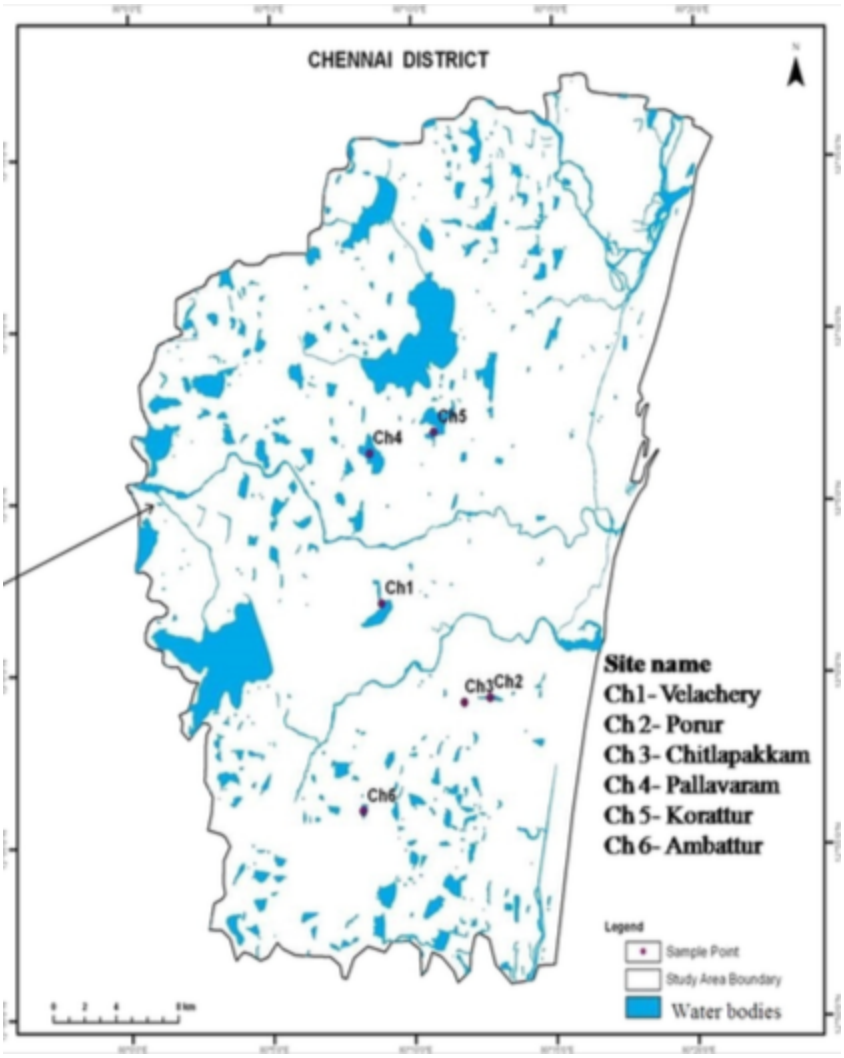


Figure 3.1 - Map showing locations of sampling sites in Chennai, TamilNadu.

Source : Sunantha G, Vasudevan N. Assessment of perfluorooctanoic acid and perfluorooctane sulfonate in surface water - Tamil Nadu, India (8)

Figure 3.1 shows the sampling points where surface water was collected from Velachery, Porur, Chitlapakkam, Pallavaram, Korattur and Ambattur in the study carried out by Sunantha, G Vasudevan, N (8). Most of the sampling locations are residential areas, in particular Velachery, a commercial location with many cosmopolitan malls and Ambattur, which covers a number of railway stations.

3.2 Concentrations of PFOA at different rivers in Chennai, TamilNadu

Table 3.2 provides a clear representation of concentrations of PFOA at three rivers namely: Cooum River, Noyyal River and Kooduthurai River. From the table the concentration of PFOA at the different sites may be compared.

Location	Concentration of PFOA
Cooum River	23.1 ng/L
Noyyal River	93 ng/L
Kooduthurai	4 ng/L

Table 3.2 - Concentration of PFOA at different rivers in Chennai, Tamilnadu
Source: Sunantha G, Vasudevan N. Assessment of perfluorooctanoic acid and perfluorooctane sulfonate in surface water - Tamil Nadu, India (8)

As seen from Table 3.2, Noyyal River has the highest concentration of PFOA followed by Cooum River and Kooduthurai. The concentration of PFOA in all three rivers is well below the permissible limit 400 ng/L.

3.3 Froth formation in Noyyal River, Chennai, TamilNadu

Figure 3.3 - Froth formation in Noyyal River, Chennai, TamilNadu.
Source: TheHindu

Figure 3.3 provides a visual of the degree of water pollution and impacts of PFOA and PFOS on quality of river water.

As seen from Table 3.2, the concentration of PFOA in Noyyal River (93 ng/L) was comparatively higher than the PFOA concentrations at Cooum (23.1 ng/L) and Kooduthurai River (4 ng/L). Noyyal River is in close proximity to dyeing and bleaching industries in Tirupur (9). The improper disposal of effluent waste and waste water treatment could be a possible reason for the comparatively higher PFOA levels in Noyyal River. Furthermore, the Noyyal River has also been observed to form froth (as seen in figure 3.3) clearly indicating the high levels of chemicals and effluents present in the water. The manufacture of the fire extinguisher, aqueous film forming foam (AFFF) using PFOA and PFOS in chemical manufacturing plants could cause froth formation in

water bodies. The improper disposal of AFFF could lead to froth formation as a result of a decrease in surface tension of water, causing it to mix with air.

3.4 Concentrations of Total PFASs, PFCAs and PFCs in Chennai

Figure 3.4 provides a visual representation of the concentration of PFCs and total PFASs in tap water from various cities in India, namely Goa, Coimbatore, Chennai and Patna. From the graph the levels of PFCs and PFASs can be compared and possible interpretations for the variation in concentrations can be made.

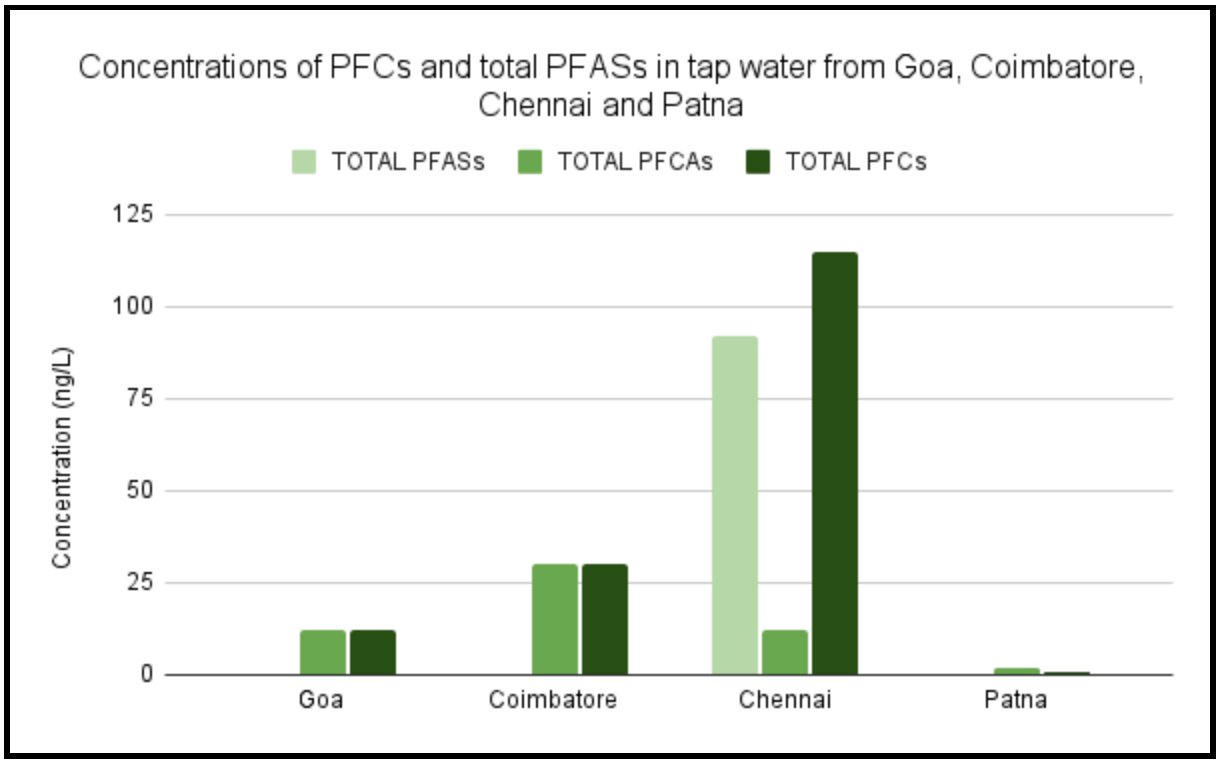


Figure 3.4 - Concentrations of PFCs and total PFASs in tap water from Goa, Coimbatore, Chennai and Patna

Source : Mak YL, Taniyasu S, Yeung L, Lu G. (10)

As seen from Figure 3.4 the concentrations of total PFCs (120 ng/L) and PFASs (90 ng/L) are comparatively higher in Chennai when compared with concentration of PFCs in Goa, Coimbatore and Patna. This could possibly be due to the fact that Chennai is a major metro city in India,

which consequently has a larger number of manufacturing facilities and possible routes of PFOA contamination such as effluent disposal, when compared with locations such as Patna which have fewer manufacturing companies and sources of PFOA contamination.

3.5 Concentrations of PFOA and PFOS in water samples from tributaries of the Noyyal, Cauvery River and other lakes in and around Chennai, TamilNadu.

Figure 3.5 allows for the comparison of levels of PFOA and PFOS in different sampling sites , moreover it compares the observed concentration to the permissible limits of PFOA and PFOS.

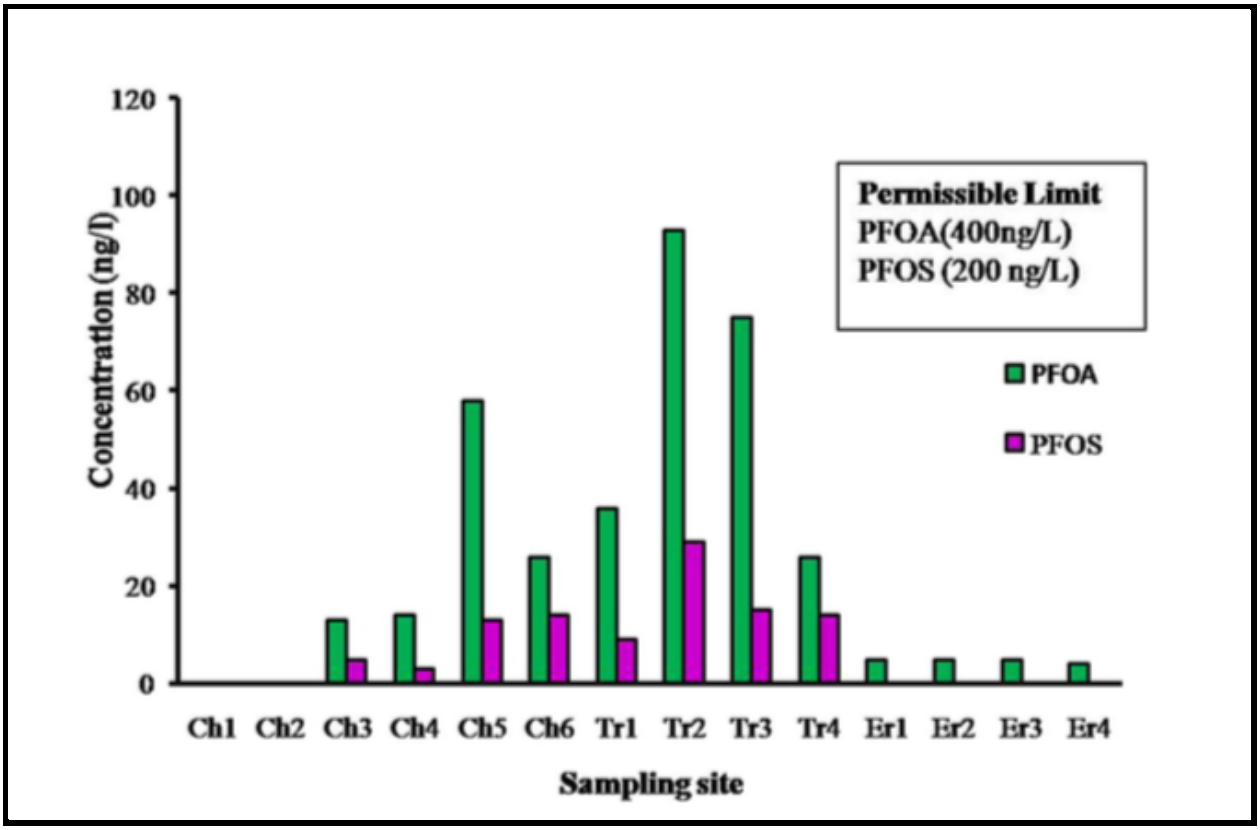


Figure 3.5 - Concentrations of PFOA and PFOS in water samples from tributaries of the Noyyal, Cauvery River and other lakes in and around Chennai, TamilNadu.

Source : Sunantha G, Vasudevan N. Assessment of perfluorooctanoic acid and perfluorooctane sulfonate in surface water - Tamil Nadu, India (8)

In an assessment of perfluorooctanoic acid and perfluorooctane sulfonate in surface water by Sunantha, GVasudevan it was found that the levels of PFOA and PFOS in water samples from tributaries of the Noyyal, Cauvery River and other lakes in and around Chennai, TamilNadu were well below the permissible limit for PFOA and PFOS - 400 ng/L and 200 ng/L respectively. The highest concentration of PFOA observed was 90 ng/L at Noyyal river (Tr2 in figure 3.5) whereas the highest level of PFOS was 30 ng/L at the same sampling site - Noyyal river.

DISCUSSION

Through the course of the research it was found that the concentration of PFOA and PFOS in the rivers of Chennai had an evident association with the number of industrial and manufacturing sites located nearby. However, the hypothesis proposed a direct correlation with the levels of PFOA and the number of industrial sites located nearby. In order for a direct correlation to be established, more in depth studies would be required. The study found that the levels of PFOA and PFOS in the studied rivers were well below the permissible limits as advised by the EPA government agency. The main cause of PFOA and PFOS contamination was found to be through water such as improper waste and effluent disposal.

In order to further understand the toxicity of PFOA and PFOS the effects of contamination on wildlife and people surrounding the rivers should be analysed. Moreover an analysis of the health effects of PFOA and PFOS from drinking contaminated water could be carried out.

A lack of data relating to concentration of contamination and exposure was evident throughout the course of research, with only a few research papers that assessed the concentrations of PFOA and PFOS contamination available. Other sources of contamination that result from contamination of water bodies such as soil contamination could be evaluated in order to provide further evidence for the widespread exposure of PFOA and PFOS and highlight the need to regulate the sources of contamination.

The bioaccumulative nature of PFOA and PFOS could be discussed as a concern for reducing contamination and eliminating contamination itself. Methodologies to reduce PFOA and PFOS contamination and exposure could be discussed with reference to the role of chemical legislation in reducing the usage of harmful chemical additives. Present chemical legislation aims to regulate and reduce the use of PFOA and PFOS through risk management and assessment. However, substituting PFOA and PFOS with alternative additives that are non bioaccumulative in nature may be more effective in making a long term impact.

CONCLUSIONS

The levels of PFOA and PFOS in the rivers of Chennai suggests a strong association with the presence of manufacturing facilities nearby that could contaminate river water by improper disposal of effluent waste and poor wastewater management. For example, the Noyyal river had a comparatively higher level of PFOA and PFOS possibly due to the dyeing and bleaching industries nearby that use PFOA and PFOS in various manufacturing processes. Rivers such as the Noyyal river with high levels of PFOA and PFOS show other indications of high contamination such as froth formation, loss of biodiversity and algal bloom.

Furthermore, the levels of PFOA and PFOS were much higher in Chennai when compared with cities such as Goa, Patna and Coimbatore. This could show that metro cities have a higher level of PFOA and PFOS due to the large number of manufacturing facilities and industrial places within the city that lead to contamination. The contamination of rivers with PFOA and PFOS concentrations are well below the permissible limits of 200 ng/L and 400 ng/L. Nonetheless, the concentrations of PFOA and PFOS could be affecting the environment and wildlife on a miniscule scale and compound over the years to an adverse problem. Surprisingly, tap water samples from Chennai, Goa and Coimbatore did not have significant levels of PFOA and PFOS but had

significant concentrations of shorter chain PFAS such as PFHxS (81 ppt), much higher than the permissible limits set by the health advisory.

ACKNOWLEDGMENTS

I would like to thank CollegePass for providing me with the opportunity to carry out my independent research project. I would also like to thank Bushnin Patel for her advice, feedback and ideas throughout the course of the project that have played a crucial role in motivating and inspiring me. I sincerely thank my chemistry teacher, Veera Menon for her guidance and helpful suggestions throughout the project. I am truly grateful for all the help that has been provided to me throughout the course of the research.

For references, footnotes and endnotes, click here.

Global Health

Hydrogen Fuel Cells: Fueling The Future

Sidhaant Kadam, *USA*

Research Question

Which source of fuel for a hydrogen fuel cell will generate the most energy and electricity-tap water, salt water, soap water, vinegar, or distilled water?

Aim

To investigate the effect of different aqueous solutions on a hydrogen fuel cell's generation of electricity & energy.

Hypothesis

If the type of fuel is related to the efficiency and amount of energy produced in volts from a fuel cell, then when tap water is used as fuel, the fuel cell would be more efficient and generate the highest voltage using tap water through the process of electrolysis because impurities such as iron, sodium, potassium, calcium, magnesium, and other ionic species are fairly mobile and give a high conductivity with low resistance.

Background

Global Warming is the gradual increase in Earth's global temperature (Shaftel, 2019). This is due to the greenhouse effect caused by increased levels of carbon dioxide and other pollutants. The Greenhouse Effect is where the atmosphere traps and gasses emitted by humans or animals. The global temperature has risen approximately 1.62 degrees Fahrenheit or 0.9 degrees celsius. DeGunther (2009) noted that most of the rising in temperature took place in the past 35 years. Some of these negative side effects have been warming up the oceans by 0.4 degrees since 1969. In the last century, the ocean level rose about 8 inches.

The scale of Global Warming's immense problem cannot be solved in a single movement. However, there are solutions out there such as hydrogen energy and fuel cells that people are researching and slowly integrating into everyday life.

There are many ways of finding hydrogen. One safe and easy way is to separate from chemical compounds such as water through the complex process of electrolysis.

Fuel Cell Functionality

The fuel cell takes hydrogen as its main source of fuel. As hydrogen is not available in my area, hydrogen was acquired by breaking down water. This is achieved through the process of electrolysis, Which is when the hydrogen and oxygen atoms in water are separated from each other using electricity. This leads to the production of bubbles of hydrogen gas in the water of the fuel cell. These bubbles are respectively attracted to the negatively and positively charged electrodes (made out of platinum-coated nickel wire). When the battery is removed, the catalytic (a catalyst is a substance that causes a chemical reaction without being affected itself) characteristic of the platinum makes the hydrogen atoms break up. This makes separate hydrogen protons and electrons. At the other electrode, the oxygen takes electrons from the metal and electrons from the old hydrogen atom and forms water. The electrons at the hydrogen electrode are attracted to the oxygen electrode. It's easier for the electrons to go through the wire than the water, so it goes along the wire, and while passing, could power a load, or light a light bulb, or in the case of my experiment, be measured by a voltmeter.

Independent Variable:

The different aqueous fuel types which were used for generating electricity: tap water, distilled water, salt water, soap water, & vinegar.

Dependent Variable:

The efficiency and voltage generated from each of the different aqueous fuels in the hydrogen fuel cells.

Controlled Variables:

Temperature of the solutions, the volume of solution, the temperature of the battery, and the temperature of other electrical components.

Materials

- At Least 30 centimeters of Nickel Wire
- 15 Centimeters of Black Colored Insulated Wire
- 15 Centimeters of Red Colored Insulated Wire
- 1 Pair of Wire Cutters
- 1 Nail
- 1 9-volt Battery
- 1 9-volt Battery Clip
- Clear Tape
- 1 Popsicle Stick
- 1 Glass
- 300 Milliliters of Distilled Water
- 900 Milliliters of Tap Water
- 50 Milligrams of Salt
- 300 Milliliters of Vinegar
- 50 Milliliters of Dishwashing Liquid
- 1 Measuring Vial
- 1 Multimeter; 7 Function, 19-Ranges Digital
- 1 Timer
- Notebook & Pen
- Ruler
- Safety Gloves & Goggles

Procedures - Building the Fuel Cell

1. Cut the nickel wire into 2 equal parts.
2. Wrap one piece of wire around a nail, leaving 3 centimeters at the end to create a coil spring-type shape and then take it off. Also, wrap the coils tight and small to improve efficiency.
3. Repeat this step for the second piece of the cut wire.
4. Now take the battery clip and snip 3 centimeters of insulation off at the ends of both the red and black wires.
5. Twist the bare section of the battery clip wires to the uncoiled part of the coil. One coil for the red wire, and another coil for the black wire.
6. Now trim 3 centimeters off of each end of the black and red insulated wire and twist them to the twisted section of each coil/battery clip connection. Taking insulated wire instead of the bare wire would prevent the chances of a short-circuit. The red insulated wire goes to the red battery clip connection and the black wire goes to the black battery clip connection.
7. Now take the electrode, as it is now called, and tape the twisted section to a popsicle stick.
8. Bend the coils down in the glass and place the popsicle stick on the rim of a glass. Make sure that the two coils are in the glass.
9. Tape the popsicle stick on to the glass.

10. Attach the 2 remaining wires to the multimeter. Take the unattached ends of each wire and twine them around both terminals. Attach the red insulated wire to the red terminal and the black insulated wire goes to the black terminal. Tape both connections to make sure that the connection is strong. The connections that were made created a series circuit.
11. Now set the setting of the multimeter to the voltage of 20 because the highest voltage would be 9 volts because of the 9-volt battery. Now the fuel cell is complete.

Procedures - Experimentation

1. To start experimenting, take the 300 milliliters of tap water and fill the glass. Make sure the two coils are in the tap water.
2. Then clip the 9 Volt battery to the battery clip, and then unclip the battery after 10 seconds. The electricity from the battery is splitting the hydrogen and oxygen molecules through the process of electrolysis. Make sure that bubbles are forming.
3. Write down the voltage that is displayed on the multimeter after 10 seconds. Then write down the voltage after 20 more seconds have passed. After these 2 readings keep writing down the voltage at 30-second increments until 5 minutes, or 300 seconds, have passed.
4. Make sure to wash the glass after every test fuel.
5. Repeat steps 1-4 for distilled water. If the battery overheats, unclip the battery and take a 5-minute break.
6. To test the saltwater take 50 milligrams of salt and mix it into 300 milliliters of tap water.
7. Then repeat steps 1-4 for the saltwater.
8. To test the vinegar water, take 50 milliliters of vinegar and mix it into 300 milliliters of tap water.
9. Now repeat steps 1-4 for the vinegar water.
10. To test the soap water take 50 milliliters of the Great Value dishwashing liquid and mix it into 300 milliliters of tap water.
11. Now repeat steps 1-4 for the soap water.
12. To make sure results are true and consistent, test each test fuel 5 times.
13. Now compare and analyze the data to see which test fuel generates the most efficient and highest voltage.

Safety Considerations

- Caution should be taken when cutting the wire as it may cause cuts to the hand and fingers.
- All wires should be enclosed with plastic casings as bare wires may lead to electrical shocks.
- Rubber gloves should be worn to block the heat from overheated batteries and/or wires.

Data Collected - Raw Data

TEST-1					
Time (S)	Tap Water	Salt Water	Vinegar Water	Soap Water	Distilled Water
10	0.97	0.98	0.68	0.75	0.81
30	0.89	0.85	0.38	0.62	0.64
60	0.8	0.55	0.15	0.53	0.56
90	0.73	0.35	0.05	0.46	0.52
120	0.69	0.3	0	0.4	0.49
150	0.65	0.13	0	0.35	0.45
180	0.62	0.05	0	0.31	0.43
210	0.6	0.04	0	0.27	0.4
240	0.58	0.03	0	0.25	0.38
270	0.56	0.03	0	0.21	0.35
300	0.54	0.03	0	0.19	0.34

Table 1

TEST-2					
Time (S)	Tap Water	Salt Water	Vinegar Water	Soap Water	Distilled Water
10	0.85	0.88	0.54	0.61	0.77
30	0.75	0.71	0.26	0.47	0.6
60	0.66	0.42	0.15	0.38	0.52
90	0.6	0.25	0.05	0.32	0.49
120	0.55	0.15	0	0.28	0.46
150	0.5	0.13	0	0.24	0.42
180	0.48	0.11	0	0.19	0.4
210	0.47	0.01	0	0.16	0.36
240	0.44	0.01	0	0.11	0.34
270	0.43	0.01	0	0.09	0.31
300	0.41	0.01	0	0.07	0.29

Table 2

TEST-3					
Time (S)	Tap Water	Salt Water	Vinegar Water	Soap Water	Distilled Water
10	0.95	0.98	0.64	0.7	0.76
30	0.86	0.8	0.32	0.56	0.58
60	0.75	0.5	0.09	0.47	0.5
90	0.72	0.28	0.04	0.4	0.47
120	0.64	0.24	0.01	0.34	0.44
150	0.6	0.18	0	0.28	0.4
180	0.57	0.1	0	0.26	0.38
210	0.55	0.01	0	0.2	0.34
240	0.53	0.01	0	0.19	0.31
270	0.51	0.01	0	0.14	0.28
300	0.49	0.01	0	0.12	0.26

Table 3

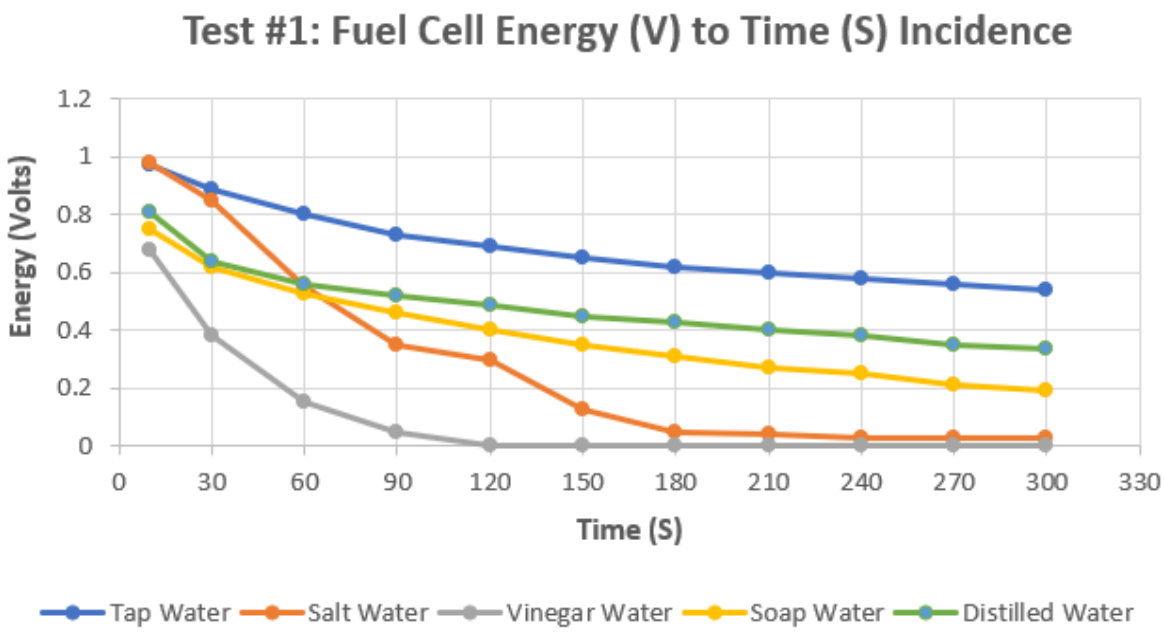
TEST-4					
Time (S)	Tap Water	Salt Water	Vinegar Water	Soap Water	Distilled Water
10	0.88	0.89	0.55	0.58	0.65
30	0.76	0.72	0.24	0.49	0.48
60	0.65	0.49	0.09	0.39	0.42
90	0.61	0.29	0.05	0.31	0.37
120	0.55	0.16	0.01	0.27	0.34
150	0.48	0.12	0.01	0.21	0.3
180	0.44	0.12	0	0.19	0.28
210	0.39	0.05	0	0.15	0.23
240	0.37	0.01	0	0.1	0.21
270	0.36	0.01	0	0.07	0.19
300	0.34	0.01	0	0.04	0.17

Table 4

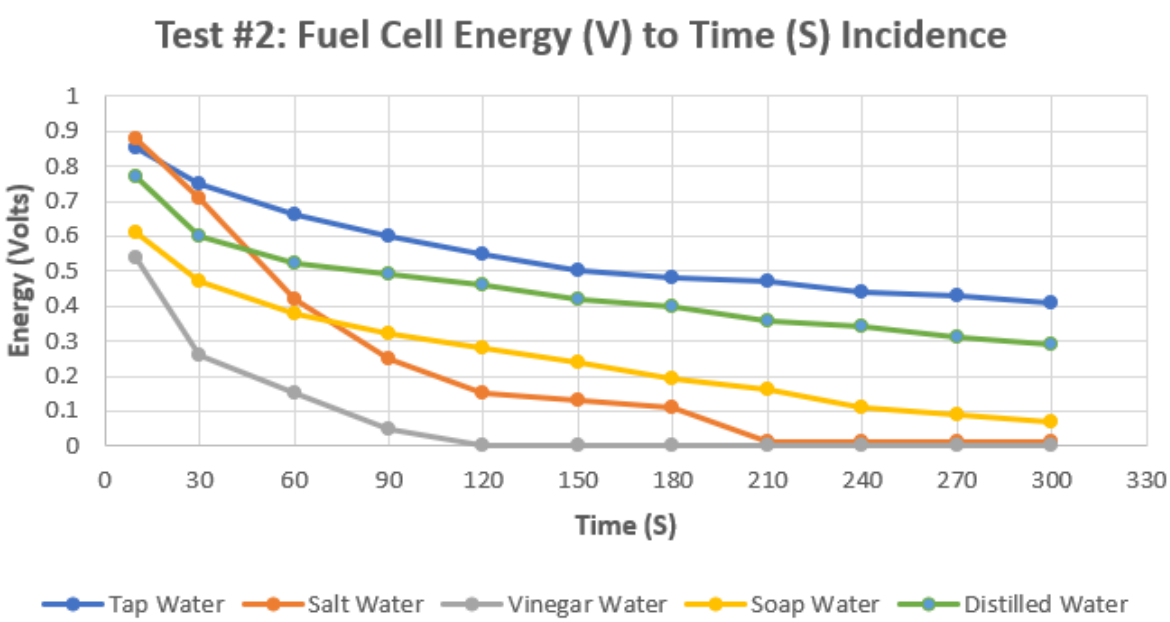
TEST - 5					
Time (S)	Tap Water	Salt Water	Vinegar Water	Soap Water	Distilled Water
10	0.95	0.93	0.68	0.67	0.77
30	0.88	0.83	0.33	0.55	0.6
60	0.75	0.49	0.09	0.47	0.54
90	0.72	0.28	0.04	0.38	0.47
120	0.67	0.25	0.01	0.35	0.45
150	0.58	0.18	0.01	0.3	0.39
180	0.56	0.1	0	0.26	0.37
210	0.53	0.08	0	0.19	0.35
240	0.51	0.05	0	0.17	0.3
270	0.49	0.01	0	0.15	0.28
300	0.45	0.01	0	0.12	0.25

Table 5

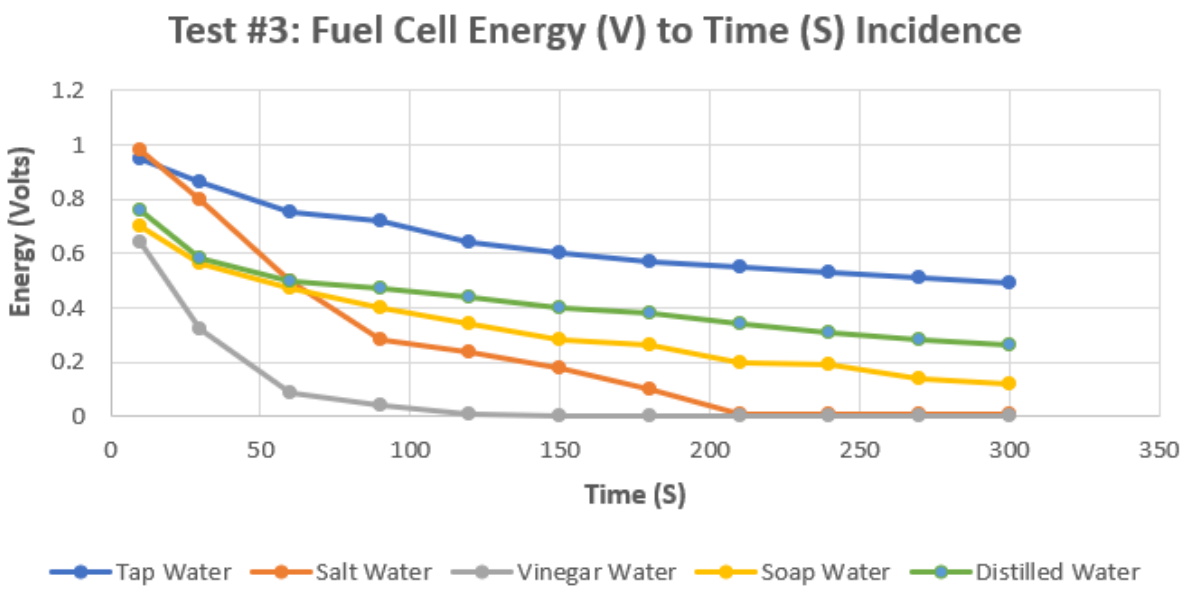
Data Collected - Graphical Data



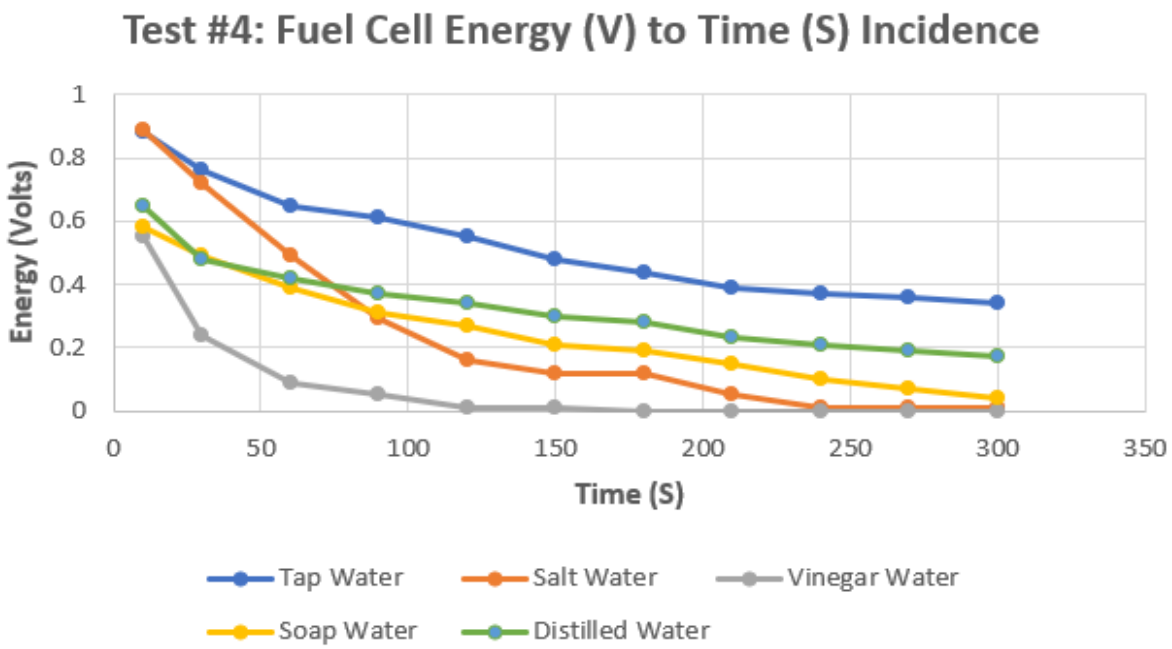
Graph 1



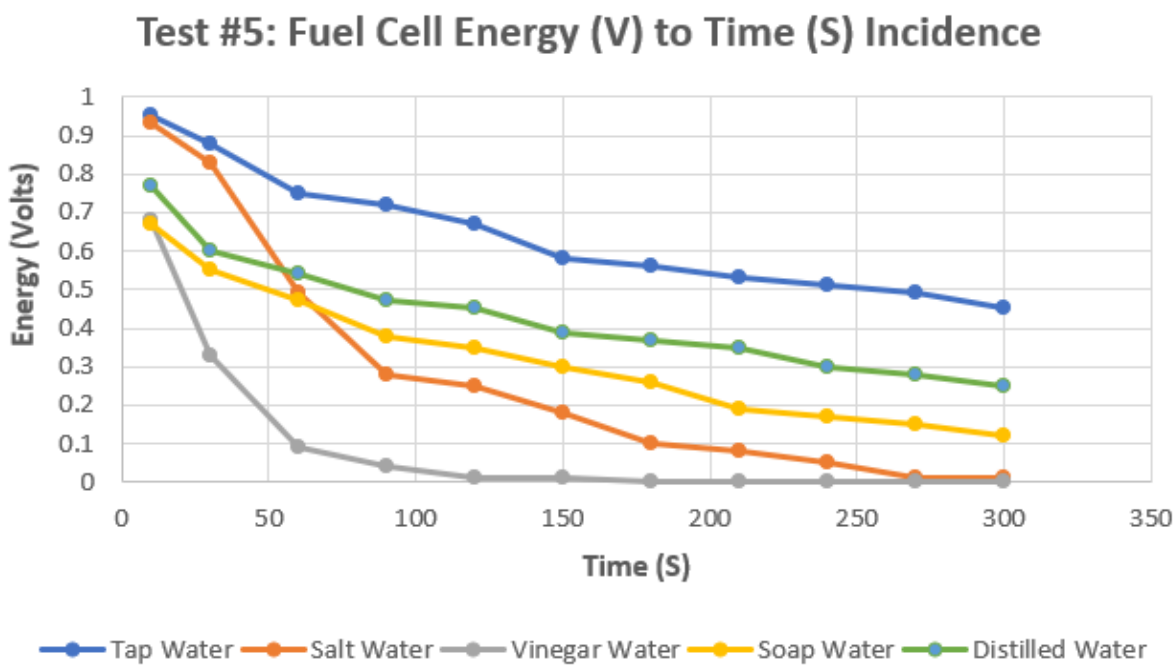
Graph 2



Graph 3



Graph 4



Graph 5

Data Collected - Test 1 Analysis

The results show that tap water is the most efficient and generates the highest voltage. The vinegar water only lasted for 90 seconds. The soap and distilled water performed similarly but better than the vinegar water. Saltwater had the highest voltage at 10 seconds but had a drastic decrease at 60 seconds. Tap water was the only test fuel that maintained a high voltage and had higher efficiency.

Data Collected - Test 2 Analysis

In test 2, tap water had the highest voltage than the other test fuels and maintained that throughout the 5 minutes. While testing saltwater, there was a loose connection between the battery clip and the battery which made the results vary. Even though there was a loose connection, the results have a similar pattern to test 1.

Data Collected - Test 3 Analysis

In test 3 the saltwater had the highest voltage but suddenly dropped at 60 seconds. Soap water and distilled water had similar voltages and had a similar pattern. The vinegar water stopped generating electricity after 120 seconds. The tap water still generated a high voltage and a higher efficiency.

Data Collected - Test 4 Analysis

Test 4 displayed similar voltages and patterns as test 1. The distilled water performed as well as the tap water except it had a sudden decrease at 30 seconds but then maintained its voltage. The vinegar water still did not perform even after 150 seconds.

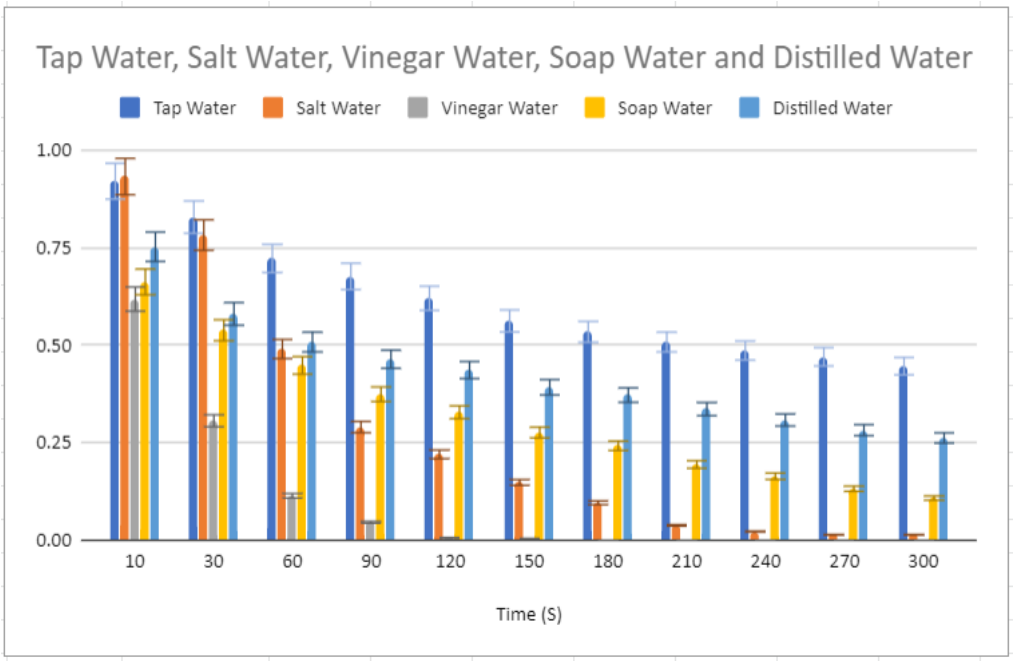
Data Collected - Test 5 Analysis

Test 5 was the best performing test for most of the fuels. The soap water and distilled water performed almost the same except for different increases and decreases at times. Vinegar water generated electricity for 150 seconds. This was the vinegar water's highest voltage out of the 5 tests. Saltwater initially had a greater peak than tap water but later dropped at 90 seconds. Throughout all 5 tests the tap water performed consistently and generated an efficient high voltage and maintained it.

Data Collected - Average Summary Analysis

Time (S)	Tap Water	Salt Water	Vinegar Water	Soap Water	Distilled Water
10	0.95	0.93	0.68	0.67	0.77
30	0.88	0.83	0.33	0.55	0.6
60	0.75	0.49	0.09	0.47	0.54
90	0.72	0.28	0.04	0.38	0.47
120	0.67	0.25	0.01	0.35	0.45
150	0.58	0.18	0.01	0.3	0.39
180	0.56	0.1	0	0.26	0.37
210	0.53	0.08	0	0.19	0.35
240	0.51	0.05	0	0.17	0.3
270	0.49	0.01	0	0.15	0.28
300	0.45	0.01	0	0.12	0.25

Table 6



Graph 6

The table & bar chart are the portrayals of the average score of all the tests for each test fuel. The Soap and Distilled Water performed very similarly. The salt and vinegar water performed better in the beginning but later on generated little to no voltage. Tap water is the best performing out of all the test fuels. It generated a very high voltage and maintained its electrical output throughout the 5 minutes. The error bars in the bar chart display the 5% error variation that could be made in the data points. But even with the error bars, the test results are consistent and reliable. Tap water would still be the best performing fuel for the fuel cell in this experiment. The line graph is a clear demonstration that tap water would generate a high voltage and maintain its efficiency. These test results support my hypothesis. To avoid errors, I made sure to keep everything consistent and true to the procedures.

Fuel Efficiency Analysis - Tap Water

When the fuel cell used tap water as its source of fuel, the efficiency and high voltage were better maintained than the other solutions. After looking at the graph, the trend is that the voltage drops rather fast at the beginning of the experiment but later begins to output energy at a more steady rate. I hypothesized that the impurities within the water might help the voltage readings because of the high conductivity with low resistance. Through the data that was collected, the consistency of the data supported my hypothesis.

Fuel Efficiency Analysis - Salt Water

When saltwater was used, the results were very surprising. While looking at the data results, the saltwater initially gave a high voltage then drastically dropped, and approached a voltage of 0. The Saltwater had impurities such as sodium, because of this, I thought that it would do as well as tap water. I was right and wrong at the same time. The high voltage at the beginning was like a jump start for a car but shortly after the high voltage, the amount of energy generated drastically dropped. because the voltage started off high, but then quickly dropped. I think this is because the salt in the water made it possible for more H20 molecules to be broken down into hydrogen and oxygen atoms.

Fuel Efficiency Analysis - Vinegar Water

The vinegar water was the first fuel to hit zero. The results and the trends in the graph portray that the vinegar hindered the fuel cell from giving off energy. Right from the start, it generated a lower voltage than the tap water. In real-life applications, vinegar water would not be a viable source because of the fast depletion of the generated energy. Vinegar and lemon juice are weak conductors of electricity due to the number of acids in it.

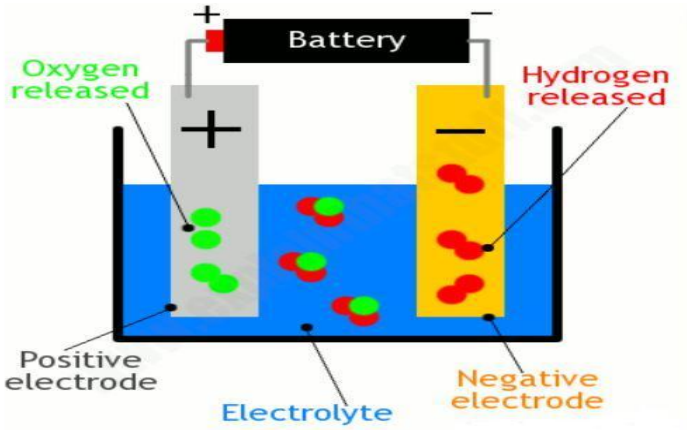
Fuel Efficiency Analysis - Soap Water

The soap water had a very similar pattern to tap water but with different values. Their lines are almost exactly the same, except for the actual values. The soap water did maintain a relatively high voltage but did later drop. This leads me to believe that soap water is a more extreme case of that vinegar. In conclusion, the soap slows down the fuel cell voltage but does not stop it as the vinegar does.

Fuel Efficiency Analysis - Distilled Water

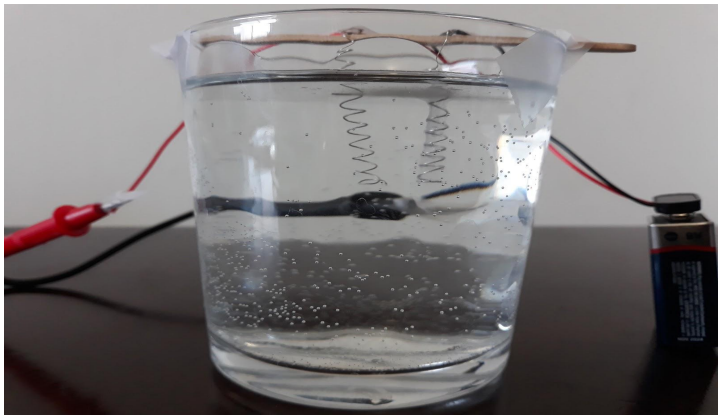
When distilled water is compared to the other test fuels, it did not perform as well as the others. The reason why the distilled water did not do as well as the other waters is because that it was distilled, it was too perfect, it did not have any impurities that could have otherwise helped the fuel cell process, such as salt that might have increased the voltage. The distilled water was too pure and the thought process of “pure is better” does not comply with the results of this experiment.

Appendix 1: Hydrogen Fuel Cell Functionality



Appendix 2: Experiment Set-Up

Appendix 3: Hydrogen Fuel Cell Set-Up

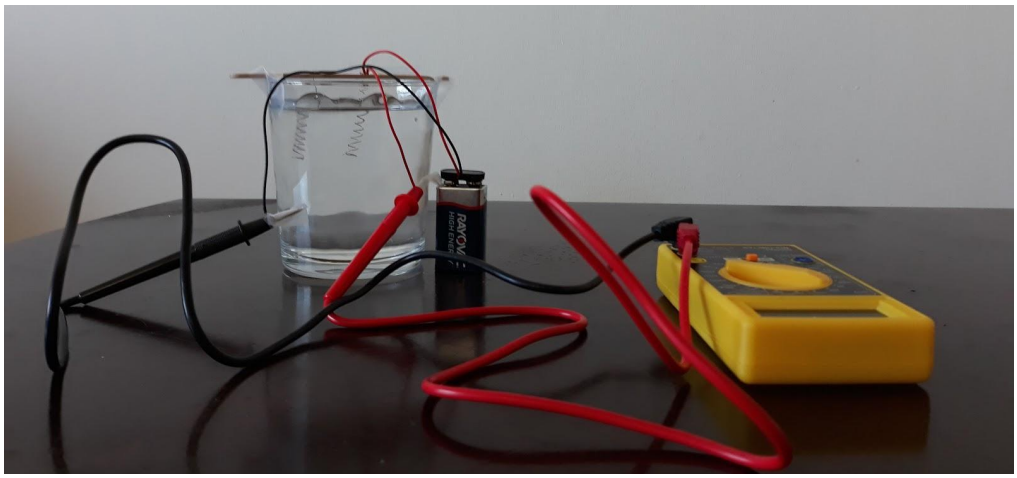


The process of electrolysis is taking place in the glass above. The streamline of bubbles is the main indication of the separation of the hydrogen and oxygen. The bubbles that are forming contain hydrogen.

Appendix 4: Electrodes

A close look at the positive electrode (red) and the negative electrode (black). The process of electrolysis is taking place due to the current from the 9-volt battery.

Appendix 5: Electrical Output Set-Up



The set-up of the fuel cell. The connections made are a series circuit. A series circuit is a closed circuit in which the current follows one path, as opposed to a parallel circuit where the circuit is divided into two or more paths.

Appendix 6: Scientist During Experimentation Process

For references, footnotes and endnotes, click here.

Biology

Ancient Cells: What did DNA Evolve from?

Darcey Joia, *United Kingdom*

Darcey Joia, having finished secondary school this year, researches the biological sciences with a passion, taking a particular interest in genetics, evolution, and cell biology.

Introduction

DNA, RNA, and proteins: three of life's most inextricably linked molecules. DNA, a double helical molecule built of ribose sugars, phosphate groups, and nitrogenous bases adenine, guanine, cytosine, and thymine paired to each other (A-T and C-G) by hydrogen bonds,[1] is "unzipped" by helicase, gyrase, and RNA polymerase during transcription.[2] Free-floating RNA nucleotides (consisting of the bases adenine, guanine, cytosine, and uracil) bind to complementary bases on the DNA template strand. RNA polymerase enzyme catalyses the formation of phosphodiester bonds between RNA nucleotides, creating messenger RNA - the key to taking genotype and making it phenotype. The mRNA travels through the cytosol toward a ribosome, made of RNA and a selection of proteins. At the ribosome, a transfer RNA, carrying an amino acid, will bind to the mRNA molecule at a start codon. A second tRNA will follow, holding a second amino acid. Peptidyl transferase, an rRNA enzyme,[3] catalyses the formation of a peptide bond between the amino acids. The first tRNA moves off, and a third binds next to the second. This process continues until a stop codon is reached, and a polypeptide created.

Through these intricate mechanisms of inheritance and genetic expression, modern life can function. Organisms, both eukaryotic and prokaryotic, in addition to some viruses,[4] rely on these macromolecules to exist. However, their utter interdependence on each other begs the question: 'How can such a system have arisen to begin with?' This chicken-or-egg question is best approached with another: 'what kind of primordial molecule could have acted as a precursor to this entire system?'

The RNA World: Making a Case

In 1962, Alex Rich postulated the existence of what is now called the "RNA World."[5] This scenario predated the first "protocell", or any other eligible candidates for life. It proposes that primitive forms of RNA played the role of the first hereditary biological molecule.

The first biological molecules on earth might have been created during catalysis reactions on the surface of crystalline minerals. These molecules would have undergone constant synthesis and breakdown – the earliest form of metabolism.[6] However, synthesis and breakdown on its own is not enough for the instigation of a stable system of information storage and expression, let alone the emergence of life. We require a molecule that is capable of self-replication. Moreover, we require a molecule that can catalyse its own self-replication, in order to achieve the stability needed for the proliferation of a suitable precursor molecule to all life.

In an analysis of RNA's candidacy for such a role, we can consider its functions as a catalyst, and as an information storage molecule. RNA is, as Thomas R. Cech describes it, "both genotype and phenotype,"[7] meaning it possesses qualities common to both DNA and proteins; it is able to store information and catalyse reactions. Evidence for the former is straightforward. In modern cells, mRNA temporarily stores genetic information in its codon sequence before translation. RNA's catalytic abilities were only discovered in recent decades.[6] In 1992, a research paper commented on lab experiments demonstrating that, once the majority of proteins in a ribosome were removed, the ribosome retained its catalytic abilities, thus indicating that the peptidyl transferase function of the ribosome is rRNA-mediated.[8] RNA enzymes are known as ribozymes. In addition, many coenzymes of the modern cell (including acetyl-CoA, NADH, and FADH, which are involved in metabolic processes such as photosynthesis and respiration), contain RNA features.[9] These coenzymes are highly conserved across organisms, and so their RNA components support the idea of a primitive RNA World. Further arguments constituting the case for this scenario comment on parsimony; it is more conceivable that a single molecule (such as RNA, with its multiple functions) would replicate in a primitive environment, rather than another nucleic acid (i.e., a direct precursor to DNA) and also a protein (required to the assist the replication of the nucleic acid) being spontaneously produced alongside each other.[7], [[1]], [[2]]

Having outlined the plausibility of an RNA World, we can begin to postulate the pathway that enabled its occurrence, and the pathway that followed.

[1[]] A pre-RNA World, consisting of precursors to the RNA precursor, is suggested to exist.[6]

[2[]] RNA has other functions in cells too. For example, "riboswitches" are involved in gene regulation.

The Emergence of Primordial RNA

How were these prebiotic versions of RNA synthesised to begin with? In the primitive solution of molecules and compounds on Earth where most prebiotic syntheses took place, known as primordial soup,[10] were free-floating nucleotides, probably similar to the ones that make up nucleic acids (e.g., RNA and DNA) today. Frequently, these nucleotides would bond. Occasionally, sequences of nucleotides that possessed autocatalytic abilities would form, enabling them to remain intact and stable for longer than others, which, subject to energy changes, would usually break down. These autocatalytic molecules were selected for in their ancient aqueous environment. Able to catalyse the synthesis of themselves, these molecules unlocked the advantages that accompanied self-replication: they could increase their frequency in the population by proliferation. This hypothesis receives support from a 2009 paper - that commented on the identification of autocatalytic ribozymes, describing it as "being able to undergo self-sustained replication in the absence of proteins."[11] In turn, they profited from having enough time gather beneficial mutations which further assisted their expansion. The nucleotides that form RNA (or perhaps more likely, similar versions of them) may have undergone this exact evolutionary pathway to eventually create an RNA World.[[3]]

On its own, this system of self-replication is simple and limited in nature. Competition between nascent nucleic acids (note that multiple systems of autocatalytic molecules might have emerged on several occasions, and probably simultaneously to each other) will have contributed to this restriction on potential. Sophistication requires separation between sets of RNA molecules. Such compartmentalisation was introduced by amphipathic molecules in the surrounding environment.[6] Amphipathic molecules consist of both hydrophilic (water-attracted) and hydrophobic (water-repulsed) parts, giving them the unique ability to form aggregates when placed in aqueous solution. A system in which a spherical aggregation of amphipathic molecules encloses a set of primitive autocatalytic RNA molecules, that permits the movement of raw materials across the membrane, but reduces competition for the selected RNA, is our earliest model of a protocell.

The Emergence of Protein Synthesis

Following the evolution of efficient self-replication and compartmentalisation comes the emergence of the peptide.[6] Protein synthesis requires a relatively elaborate translation apparatus, which today involves a template molecule (mRNA), a molecule to carry and position the appropriate amino acids (tRNA), and an enzyme to catalyse the formation of peptide bonds between amino acids (the ribozyme peptidyl transferase).[3] In the lab, it has been demonstrated

[3[]] Interestingly, a 2015 article from NASA detailed the discovery that uracil, thymine, and cytosine (three of RNA's bases) can be synthesised "in a laboratory under conditions found in space." It seems that RNA's bases might have originated from celestial matter that made its way to Earth![12]

that RNA molecules, consisting of high frequencies of codons for a specific amino acid, can bind tightly to it.[6] Via RNA that served as ancient tRNA, the genetic code was possibly established. Primitive tRNA could bind to amino acids that had diffused across the membrane of the protocell, and then bind to RNA that mimics modern mRNA. An assortment of peptides could form. If a particular set of RNA molecules inside a protocell had the appropriate codon sequences to encode any useful (e.g., enzymatic) peptides, this would be entirely to the cell's advantage. An early version of peptidyl transferase may have also arisen, catalysing the formation of peptide bonds.[6] Eventually, RNA's catalytic capabilities became less required; the molecular versatility of peptides (20 amino acids compared to 4 nitrogenous bases)[13] meant increased efficiency and specificity. Peptides could ultimately outcompete the molecules that synthesise them.

The shift from one primary catalytic molecule to another increased the energetic and functional capacity of the protocell.

An outline of our protocell thus far is: a membrane built of amphipathic molecules surrounding a mixture of RNA, peptides, and a miscellany of raw materials. Here, we shall begin to approach an answer to the question: where did DNA come from? The evolution of a complex system of translation is already underway. Through self-replication and mutation, a self-sufficient, complete RNA genome looks to be just on the horizon. In fact, it would seem that, guided by the necessary selection pressures, the protocell should begin to synthesise larger, more intricate proteins, and be able to start becoming larger and more intricate itself. Hence, we ask why DNA was needed in the first place.

The Emergence of Sexual Reproduction and DNA

The postulated protocell contains single-stranded RNA. It contains a single copy of each RNA gene (where a gene is a sequence of codon bases coding for a single peptide). Therefore, the cell is haploid. A haploid cell is vulnerable, as any breakage in a genetic molecule could lead to the loss of an essential function. By increasing ploidy (e.g., by increasing the number of copies of each gene in the cell to induce diploidy or polyploidy),[15] the risk of a nucleic acid breakage leading to the inhibition of a gene's function is reduced, as a functional homolog is likely to remain. [[4]] However, increased ploidy has heavy bioenergetic and molecular demands, and may not ultimately benefit the cell. A 1984 paper investigated this problem, discussing the optimum ploidy of a protocell, whilst also identifying the origins of sexual reproduction. The paper states that it is "advantageous [for a protocell] to fuse periodically with another protocell to restore reproductive ability".[16] Essentially, the paper argues that the protocell remains in a state of haploidy to conserve energy. The protocell will, however, frequently "fuse" with another haploid protocell. At this point, the cell is diploid, but only temporarily. Any damaged RNA genes can be replaced by a replica of its homolog from the other cell. The protocell now contains at least one set of undamaged genes. It can now replicate

[4[]] For a comparison of genetic stability between haploid and diploid cells, see the work of Evstratova E. S., Mishra K. P., and Petin V. G. for more.[14]

the functional set of RNA, and split into two daughter cells. This process is viewed as the origin of sexual reproduction, whilst also echoing the cell cycle as we know it today.

Following the evolution of this cellular reproduction comes, finally, the emergence of the much-anticipated double-stranded DNA. The reasoning behind this transition is surprisingly simple. Alberts et al. comment, "the cells of the RNA world would presumably have been much less complex and less efficient in reproducing themselves than even the simplest present-day cells."[6] This is, in part, due to the increased usage of peptides and proteins in today's cells compared to during the RNA World. However, it is fundamentally linked to the structure of RNA. RNA is unstable in comparison to DNA, and therefore more prone to mutation and less efficient at carrying and passing on accurate hereditary information.[17] RNA possesses a hydroxyl (-OH) group on the second carbon of its ribose sugar in its sugar-phosphate backbone.[18] The adjacent phosphodiester bond is susceptible to attack from the hydroxyl group.[19] Furthermore, the replacement of the base uracil (in RNA) with thymine (in DNA) occurred because thymine is less susceptible to mutation – the presence of an extra methyl group increases stability.[20] Uracil is less energetically expensive than thymine,[20] however. This might explain its presence in RNA. Lastly, the double helix structure itself provides increased stability.[6] The argument goes that DNA is all round more suited to the role of genetic information storage than RNA is. It is more efficient, and less likely to result in mutation. The details of the mechanisms of the transition from RNA to DNA are uncertain. The process is thought to be complex, involving the need for the evolution of DNA replication enzymes and other necessary proteins.[21] G. S. Diemer and K. M. Stedman even explore the likely possibility that ancient viruses were involved in the conversion of one genetic system to another: many researchers look to viral replication systems for answers.[22] The exact pathway taken by RNA to become its double-stranded cousin is shrouded in debate.

Conclusion

The RNA World came and went before the last universal common ancestor (LUCA) appeared, predating life as we know it. Scientists look to the macromolecules of modern cells and see living fossils in the form of RNA. Until recently, little was known about this pivotal molecule. DNA came from an astonishingly simple nucleic acid with the vital ability to replicate itself, all whilst carrying hereditary information – something DNA is yet to achieve.

The questions explored by this paper are paramount to evolutionary biologists, geneticists, virologists, and an innumerable number of researchers. Investigating what DNA evolved from tells us why DNA behaves the way it does, and permits a deeper understanding of life's genome.

For references, footnotes and endnotes, click here.

Social Justice

Parental Prejudice Toward the LGBTQ+ Community: Problems with Heteronormativity and Children's LGBTQ+ Media Exposure

Olivia Jaramillo, *United States*

Olivia Jaramillo, an incoming senior at TERRA Environmental Highschool and a prior AP Capstone Research student.

INTRODUCTION

Michael Warner, an American social theorist, conceived the term heteronormativity. It describes the predominant belief that there are two distinct genders, female and male, who adhere to gender roles and naturally, romantically, and sexually partner with one another [23]. Essentially, society reflects heteronormative beliefs by assuming everyone is inherently heterosexual, attracted to the opposite sex, and cisgender, assigned with their sex at birth. However, Warner notes that heteronormativity "...clothes itself in goodwill and intelligence", indicating that it is often unintentional in nature [23]. Heteronormativity is generally omnipresent and insidious, so it can permeate into the family sphere. Heterosexual parents often uphold their children to sexuality and gender standards, unwittingly or not.

LGBTQ+ media representations challenge common-held conceptions about sexuality and gender. In the past decade, LGBTQ+ narratives have gradually surfaced in children's television and books. Despite this increase, it remains unclear if parents present this media to their children. This research considers whether a parent's heteronormative beliefs determine whether they expose their children to LGBTQ+ media.

LITERATURE REVIEW

Through the formative years of elementary school, parents strive to create an optimal home environment for their children. From monitoring media usage to encouraging extracurricular activities, modern-day parents concentrate on laying down a positive foundation for their children's growth [5]. In doing so, parents often overlook their subconcious renforcement of heteronormative standards within their households through the media they introduce to their children.

The enforcement of heteronormative ideology by parents, while common due to societal pressures, can lead to various consequences. For example, anxieties about public judgement stifle acceptance of gender non-conformity or homosexuality in households. One father expressed his apprehensions: "Say if I'm in Walmart and I buy a doll for my son, I got critics, you know what I mean?" [21]. Parents fear that deviations from heteronormativity both degrade their abilities in child-rearing or result in the bullying of their children [21]. However, researchers contend that LGBTQ+ youth feel stifled by this supposed protection, finding that emotional distress increased in young people who experienced "heteronormative surveillance, scrutiny, and policing by family members." [12]. This study assesses if this form of parenting influences LGBTQ+ media exposure to children.

Children's Media and Heteronormativity

Replete with fairy tale plots and gender-specific marketing, media for the child demographic has largely reinforced traditional views of gender and sexuality. Disney classics idealise heterosexual relationships. *Beauty and the Beast*, *A Bug's Life*, and *The Little Mermaid* all culminate in a happy ending rooted in a heterosexual relationship [18]. Even recent Disney Princess films exemplify these same ideals: romantic, self-determination, or both [13].

LGBTQ+ stories have been gradually emerging in the realm of children's television and books. In 2014, the cartoon *The Legend of Korra* concluded with the protagonist holding hands with another female character [14]. Precedents, like this show, paved the way for unambiguous LGBTQ+ representation for kids. Similarly, children's chapter books with LGBTQ+ storylines are coming to the fore. For example, *George* by Alex Gino follows the story of a transgender girl who comes out as Melissa [7]. LGBTQ+ representations have progressively gained traction, however, they remain outside of the mainstream. Although the volume of LGBTQ+ media for youth has increased, it is parental factors that determine their reach.

Parents and LGBTQ+ Children's Media

Parents have differing opinions on LGBTQ+ media based on many factors. Holiday, Bond, and Rasmussen evaluated several parental mediation responses regarding a movie trailer of a transgender coming-of-age story for children ages 12-18 [9]. They found that income, education, gender, and religiosity did not generally affect parental censoring of the trailer [9]. Rather, parents with conservative ideologies were more likely to censor the media compared to liberal parents who favored active mediation, instigating conversations about media. [9]. Similar mediation is especially prevalent in younger age groups, considering that 66% of 8-to-10-year-olds have rules regarding which shows they can watch on television [17]. Notably, political affiliations and age might influence parents' decisions to show their children LGBTQ+ media.

Additionally, when managing media for their children, parents have misapprehensions about LGBTQ+ education. According to Robinson, parents fear that discussing LGBTQ+ identities will prompt children to adopt them [18]. She argues, however, that "...the constructed silence, irrelevance and taboos in terms of talking about sexuality with children and youth, often in the name of protection, have ironically contributed to their vulnerability to abuse and other risks" [18]. LGBTQ+ youth want verbalized support from their parents, which this apprehension of discussion hinders [19]. When a 4th and 5th-grade teacher discussed the word queer while reading in class, a parent "...argued that the kind of teaching Linda did...introduced new information that children weren't aware of, didn't need to know, and actually could harm 'sensitive children' like her daughter" [8]. While most parents in that classroom affirmed LGBTQ+ content exposure to their children, some parents understate the importance of teaching children about the LGBTQ+ community. They question whether it is necessary to introduce LGBTQ+ media content, regardless of their child's identity.

The Implications of LGBTQ+ Media Exposure to Children

When parents implement restrictive mediation with heteronormative intentions, it has long-lasting impacts on prejudice and identity confusion. Children determine media 'appropriateness' through their parents' commentary [22]. In the eyes of parents, young children may only view genres of media excluding LGBTQ+ themes. If their parent deems it inappropriate, children learn their parents' stance, which entrenches ignorance among children.

Demonstrating the lack of exposure to LGBTQ+ identities, Van der Toorn, Pliskin, and Morgenroth indicate that in the early formative years of childhood, social environments, common media representations, and peers boost heteronormative ideology [24]. Thus, it is plausible that home environments or the lack of LGBTQ+ media shown to children contribute to these prominent heteronormative beliefs of children. Heteronormative beliefs could then transform into

explicit and implicit homophobia and transphobia, contributing to the bullying of other peers [24].

Moreover, children who identify in the LGBTQ+ community benefit from representation in the media. When evaluating the reactions of young people aged 13-21 on a gay kiss in a show, LGBTQ+ youth relayed empathy, finding their identity in the characters and felt positive emotions of hope, higher mental energy levels, and pride in their in-group affiliations [3]. By contrast, the heterosexual youth who watched the same scene demonstrated a boomerang effect, where they had more negative sentiments toward LGBTQ+ people and issues and reported a disgusted response [3]. These results imply that representation only benefits LGBTQ+ identifying youth. However, the age group must be considered. In an elementary 4th grade class, after reading the book *George* by Alex Gino, students were allowed to ask questions to the author, who uses gender-neutral pronouns [7]. Although the students did not initially comprehend the pronouns, the teachers taught them to understand expressions outside gender constructs [7]. As demonstrated, with proper media representation and conversation, younger children transcended preconceived heteronormative boundaries.

The Present Study

A 2019 National School Climate Survey by GLSEN, an American education organization, discovered that 68.7% of LGBTQ+ students in grades 6-12 experienced verbal harassment based on sexual orientation and 56.9% on their gender expression [11]. With this critical state of bullying and discrimination, an early understanding of LGBTQ+ issues for elementary-aged children is crucial. Reaffirming this necessity, older LGBTQ+ youth report the importance of the media on their well-being: "But...at a time when I was finding it hard to identify with straight characters, I would turn to *Queer as Folk*. I think just turning to some media is a form of escapism from the harsh reality that is the heteronormative, the heterosexist world that we live in" [2]. Youth benefit from seeing a media role model, but parents often have misconceptions about LGBTQ+ media [4]. Deliberately or not, parents generally mold opinions on media and enforce heteronormativity in their houses, regardless of the positive influence LGBTQ+ media might have on their child's identity or the perception of their peers.

While prior research investigated parental reactions to LGBTQ+ media and explored the presence of heteronormativity in parental viewpoints, there are gaps researchers have not considered. While relevant literature factored in age, education, gender, religion, and political affiliation to measure restrictive mediation on LGBTQ+ media, they have not considered how heteronormative beliefs influence parental views on this media [9]. Essentially, parental heteronormativity and LGBTQ+ media for children have been researched extensively, but separately, from one another. Furthermore, the literature has not investigated the frequency to which parents show LGBTQ+ media to their children or if they choose to exclude it entirely. Instead, researchers have surveyed parents on the strength of mediation based on scenarios [9]. This

research does not clarify if parents had previously presented this media to their children, only their to do so. Therefore, to address these gaps, this paper aims to explore: How heteronormative beliefs influence the extent to which parents introduce LGBTQ+ media to children ages 6-11 in their households? The researcher hypothesizes that despite other factors like age, relation to children, religion, political affiliation, or ethnicity, heteronormative beliefs would be the predominant factor that lessens LGBTQ+ media exposure to children.

METHODS

This study uses a quantitative research method mixed with some elements of qualitative study. The online survey determines how often parents show their children LGBTQ+ media and if heteronormativity impacts this decision over other factors. Since demographics could influence parental decisions, they are considered first before drawing conclusions on heteronormativity. To understand the parents' perspectives from their own words, the method is mixed and has a free-response question asking parents to comment on survey themes.

Participant Recruitment

Parents of children ages 6-11 were recruited through local elementary schools in South Florida by asking teachers to send the Google Forms survey through class platforms to parents. Using this surveying method, 37 parents responded. The age range of children in this study is within middle childhood, ages 6-12, but 12-year-olds were omitted as they are not in elementary school. Middle childhood reflects the research intentions since, "counter-stereotypic messages received from the media during middle childhood are probably particularly likely to be processed effortfully, resulting in more lasting effects" [10]. Additionally, elementary school parents tend to have more control over the media their children watch than parents of older children, proving it is necessary to investigate them in particular [17]. For the study, only parents not a part of the LGBTQ+ community were considered. While heteronormative societal pressure could influence sexual and gender minorities, LGBTQ+ media exposure to children might be more notably absent from heterosexual and cisgender family structures [24]. For this reason, a question asked the participants if they are a part of the LGBTQ+ community. The response is excluded.

Design and Survey Content

The first question on the online survey was mandatory. It provided the informed consent form and asked the participants to agree with a check box (Appendix A). It notified participants that they could leave the survey at any time, skip questions, and that their information is entirely anonymous. The survey separates into four parts and consists of 28 questions (Appendix B).

The first part of the study, Demographic Information, gathers the parent's general information through multiple choice and fill-in questions. This included their age, relation to child/children, if they are in the LGBTQ+ community, religion, political party, political ideology, and race/ethnicity. A previous study used similar covariables when studying parental mediation toward a transgender film trailer [9]. Thus, it is notable to include demographics to ascertain if heteronormativity predominantly influences parental decisions to show their children LGBTQ+ media or if demographic covariates are more significant. The final question in this portion asks the parents to assign a number to each child with their age and gender (e.g., Child 1: 10, boy Child 2: 7, girl). This accounts for differences in parental perspectives based on the age and gender of their child. For example, it has been observed that older children have fewer media rules regarding content [17].

The following subsection of the survey, Parental Mediation, determines how much LGBTQ+ media parents show to their children. To gauge the parent's mediation habits, there was a primary question asking, "How often do you introduce media to your child/children? (e.g., Recommend movies, check out books from the library for them, show them TV shows, etc.)" with a five-point Likert scale from *never* (1) to *very often* (5). If parents answer *almost never* (2) or *never* (1), then they will be excluded from the study. Parents who do not present media to their children would naturally not present LGBTQ+ media either. The main question, the LGBTQ+ media exposure question, is "How often do you show LGBTQ+ media to your child? (TV shows, the news, books, etc.)" with the same range as the prior question. High scores in this category indicate that parents have shown more LGBTQ+ media content to their children than the lower score. The final question presents the statement, "I would let my child/children watch a show with an LGBTQ+ character" with a seven-point Likert scale from *strongly disagree* (7) to *strongly agree* (1). Essentially, this situational question would demonstrate if there is a disconnect between the actuality of LGBTQ+ media exposure versus what they would hypothetically allow.

Views on Gender and Sexuality, the third subsection of the survey, measured the heteronormative beliefs the participant holds. The Heteronormative Attitudes and Beliefs Scale (HABS) incorporated in this section is a self-report, 16-item measure divided into an Essential Sex and Gender Subscale and a Normative Behavior Scale, which assesses the participant's traditional beliefs regarding gender and sexuality [6]. The seven-point Likert scale questions were scored based on how traditional the viewpoint is, the highest number being the most heteronormative (e.g., People are either male or female: *strongly agree* (7) and *strongly disagree* (1)). It is reverse coded for negatively worded items. The mean of the items determined the participant's heteronormativity

score, with a higher score representing the higher level of heteronormative beliefs. Studies utilize HABS due to its high internal consistency, reaffirming its efficacy for this study's purposes in deriving a heteronormativity score [15].

The subsection, Your Comments and Opinions, considers any opinions parents have concerning LGBTQ+ media and their children. In this subsection, there was one free-response question for participants to fill in. The question began with, "Write any comments or opinions about the themes discussed in the survey...." Then, there were three example questions to gauge parents' beliefs further. As demonstrated in Stacy and Padavic's research, open-ended questions help elaborate parental views [21]. Unlike the in-person interview structure utilized in Stacey and Padavic's study, however, parents typed their responses since it is an online survey.

RESULTS

To evaluate the data, two responses outside the criteria were removed from the initial 37 responses. One response answered yes to the question asking if they were a part of the LGBTQ+ community, which was deleted to only consider heterosexual and cisgender parents. Another question that determined the usability of the parental responses asked, "How often do you introduce the media your child is exposed to?" Participants answered *sometimes* (31.4%), *fairly often* (40%), and *very often* (28.6%). One deleted response answered *almost never*, which suggests they do not present their children LGBTQ+ media due to that reason, not heteronormativity or another factor.

Evaluating Demographic Factors

The research aims to ascertain if a parent's heteronormativity impacts the extent of LGBTQ+ media exposure their child receives. However, it is crucial to evaluate if other factors influence this as well. Therefore, each demographic question was compared to the LGBTQ+ media exposure question in PSPP, a free statistical software based on SPSS. The frequencies and proportions of the sample were calculated to represent each categorical variable. For continuous variables, like age, means and standard deviations were calculated. Association to how often they show children LGBTQ+ media was evaluated with a Chi-squared test for the categorical variables since both variables are at a categorical or ordinal level and each variable consists of two or more groups. For the ratio variables, it was evaluated with a Spearman's rank since the two variables are measured on an ordinal or ratio scale and they represent paired observations.

See Table 1 for Data

Evaluating Heteronormativity

After testing the demographics, the research question was investigated through a Spearman's rank test since the independent variable, the heteronormativity score, is a ratio variable, and the dependent variable, the LGBTQ+ media exposure score, is ordinal. It also met the assumption that it represents paired observations. Compared to the significance level $\alpha = 0.05$, the test results provided sufficient evidence to suggest a negative correlation between a parent's heteronormativity and their children's LGBTQ+ media exposure, $r_s(33) = -0.53609$, r=0.0009. Therefore, there was a trend in the parents who have a high heteronormativity score to have a low media exposure score, and vice versa.

Many written responses also reflected heteronormativity as a clear indicator of their mediation. One father typed, "Children should be confined to traditional gender roles in order to help shape their identities. LGBT should be discussed in the household and has no place in the media for children." Likewise, a mother who answered that they never show their children LGBTQ+ media stated, "I believe what happens to some people is an upset in hormone levels. I do NOT like when LGBTQ community wants to force their ideas on the public through media." Parents with less heteronormative views were more likely show their children LGBTQ+ media. A mother who answered *fairly often* stated, "If my youngest son likes a Disney princess then I will buy him the Disney princess. Seeing same sex couples in children's programming is always a plus. I want my children to not live in a bubble and to not feel like they have to 'fit in' society." Another parent bolstered this sentiment saying, "I believe that they could watch appropriate shows talking about LGBTQ so that they understand that it's real and can happen."

Further Investigating Parental Beliefs

Figure Ix
Actuality

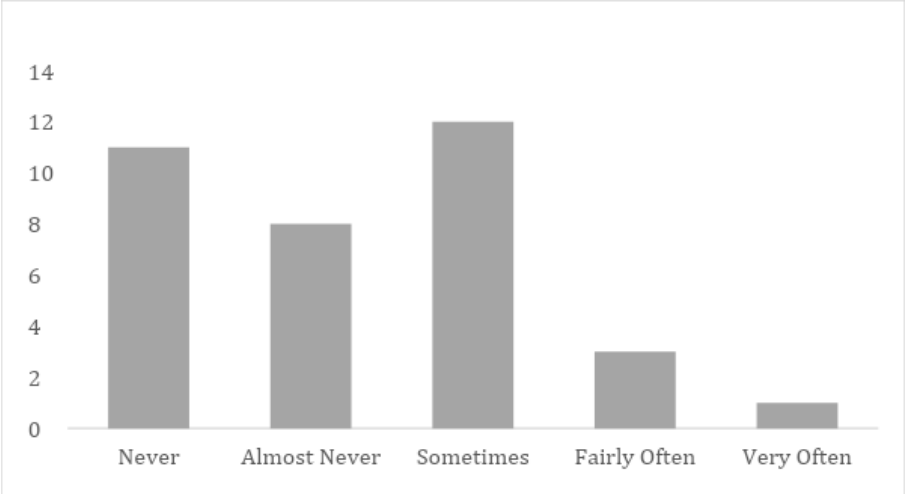


Figure Iy
Intentions

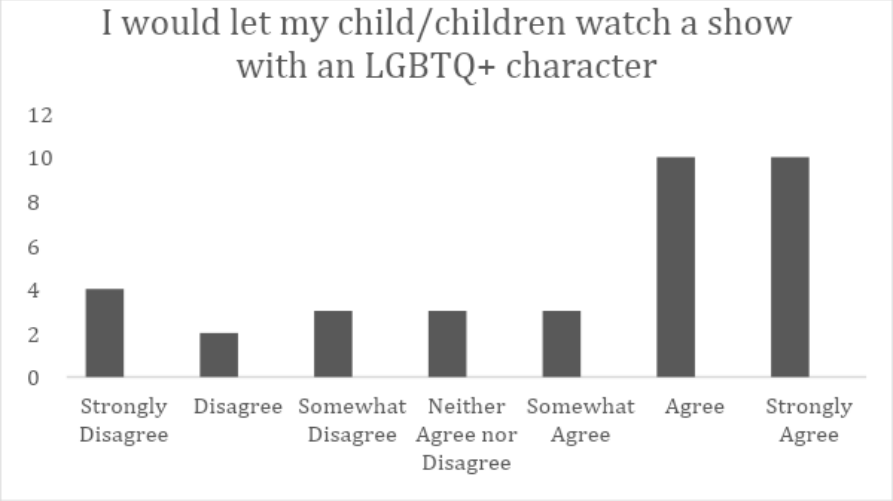


Figure Ix and *Iy* consider if there is a disconnect between how much parents show their child LGBTQ+ media and if they would be willing to show this media. The final question of the parental mediation subsection (*Figure Iy*) is below the responses to the LGBTQ+ media exposure question (*Figure Ix*). The light bars trend toward *never*, while the dark bars lean toward *strongly agree*. The majority of parents favored presenting LGBTQ+ media, even if they currently have not. Several parents explained a potential reason behind this observation when admitting to a lack of knowledge, or impartiality. One father said, "Don't know where to find LGBTQ+ media," and a mother stated, "Never thought of any of these questions regarding my children and LGBTQ+."

DISCUSSION

The Spearman's rank test and the subsequent qualitative responses supported the hypothesis that heteronormativity significantly influences LGBTQ+ media exposure over other demographic factors. As seen in *Table 1*, while religion had a statistical significance, it was considerably less than that of heteronormativity. The qualitative responses provided support for other factors like age and political party/ideology, but they lacked statistical relevance. *Figures Ix* and *Iy* suggested that the majority of parents would show their child LGBTQ+ media but have not.

As discussed alongside *Figures Ix* and *Iy*, some parents did not know where to find LGBTQ+ media; hence, it was their lack of awareness, not their heteronormativity that hindered them. After all, this media remains relatively niche, especially in children's programming and books. However, had this limitation been stronger, even parents with low heteronormativity scores would have had a low LGBTQ+ media exposure score, which would have invalidated the hypothesis. This introduces the "insidious" characteristic prescribed to heteronormativity [24].

Some parents may not have noticed their double-standards or biases toward LGBTQ+ media and identities. They did not consider LGBTQ+ media in relation to their child, with one parent stating, "Never thought of any of these questions regarding my children and LGBTQ+." Prior research also established that parents are surprised by questions regarding their children in this light since heteronormative assumptions prevent them from considering their child departing from these standards [21]. Another example of this unconscious heteronormativity was when a parent described the media as being "not necessary for a child." They might not prescribe that description to a heterosexual couple in a book or movie for its 'necessity' there would be self-evident.

Although the child's age did not appear statistically significant in *Table 1*, some parents vocalized that LGBTQ+ media is inappropriate for young children in the written portion (*Table 2*). The LGBTQ+ community is seen as an inherently adult theme, dissuading parents from broaching these topics. Robinson states, "The presumption that children are asexual, 'too young' and 'innocent' to understand sexuality is contradicted by the fact that the constructive of heterosexuality and heterosexual desire is an integral part of children's everyday experiences..." [18]. This quote illustrates the contradiction of believing children cannot comprehend sexuality, while children's media still depicts heterosexuality. A parent in this survey stated, "They don't need that confusion at such a young age," which further reflects how parents believe LGBTQ+ media is confusing, yet maintain that heterosexual counterparts are comprehensible to children.

Aside from themes of heteronormativity, *Table 1* documents a notable correlation with religion. This finding contrasted with the study of Holiday, Bond, and Rasmussen, where they found that religiosity did not make a parent more willing to censor a film trailer that featured transgender adolescents [9]. Additionally, while not statistically significant in *Table 1*, political ideology was expressed as a reason behind not showing children this media. This connects to their research, which found that parents with a conservative ideology have more support for the censorship of movie trailers featuring transgender adolescents [9]. However, the current study departs from these findings since the qualitative quote reflected a sole parent's view.

While heteronormative beliefs were the predominant statistical reason to not show LGBTQ+ media, there were tangential areas considered through the parents' words and comments.

Limitations

This study contained several limitations. First, the sample represented a population in South Florida, which accounted for the predominance of Hispanic/Latino responses. Therefore, this study cannot be generalized to the United States population of parents who reflect different demographics. Also, the sample size of 35 parents is too small for a generalizable conclusion. However, this study still provides a valuable insight on parental views surrounding LGBTQ+ media exposure to their children.

Qualitatively, the online survey structure limited this study. Rather than conducting a traditional interview, the participants typed their responses to the open-ended question. This may have dissuaded parents from commenting or hindered communication. To rectify this, a researcher could elect to first distribute the online survey, and then conduct interviews with willing participants.

Also, the question asking parents to state their child's gender and age garnered incomplete or blank responses. Presumably, this line of questioning was unclear for some parents, or, even with the reassurance of anonymity, parents may have neglected to answer this question for personal reasons. Future research should split up this question to ensure less confusion. Another limitation with questions dealt with the wording of the LGBTQ+ media exposure question. Since it was self-reported, the accuracy could lower due to a social desirability bias. Parents may have reported showing more LGBTQ+ media to children than they do to appear more socially conscious. A supplementary question asking parents to give examples of such media would rectify this limitation. Or likewise, the Marlow-Crowne Social Desirability Scale could be included within the study to exclude biases stemming from this self-report question [16]. This study elected to exclude this measure for survey length concerns that would impact the attention span of the participant.

CONCLUSION

Ultimately, this research aimed to shed light on the complexities of parental decisions behind LGBTQ+ media exposure to their children, focusing on heteronormative views. The qualitative and quantitative data indicated that a parent's heteronormativity negatively correlates with the extent of media exposure children receive. Additionally, while the data revealed a slight correlation with religion, other demographics did not correlate. This signifies that other factors may not be as significant as a parent's heteronormativity levels. The results further indicated that while some parents expressed difficulty finding such media and scored low on the media exposure, that did not overwhelmingly influence the data. The study's findings address the notable gap in the previous literature where heteronormativity has not been studied with children's LGBTQ+ media exposure.

To promote diverse media options for children, these findings imply rectifying underlying heteronormative prejudices of parental figures. Educators, for instance, can promote LGBTQ+ media to parents and their children. Researchers demonstrated the effectiveness of educators integrating LGBTQ+ media in the class while addressing hesitations parents held. When a parent questioned the inclusion of transgender people in a class reading, the teacher noted, "I tried to explain my perspective of teaching inclusively and why that's important and that a child should see a reflection of self in what we do in school..." [8]. By addressing some misconceptions parents hold, it provides an opportunity for a greater understanding.

Another similar mediation to address heteronormativity in parents lies in organizations, like Parent Teacher Associations (PTA). A study used the PTA as a means to educate parents on measures to improve students' dietary and physical activity at school [20]. Therefore, it would be plausible for school PTAs to give informative sessions on how to reframe heteronormative assumptions. This research essentially implies the need for direct communication with parents to address their heteronormative tendencies surrounding media content.

Emerging from this research, there are various implications for further inquiries. Future researchers should investigate the differences between the accessibility of LGBTQ+ children's media compared to its traditional counterparts. As some parents in the sample expressed difficulty locating this media, an in-depth investigation could demonstrate possible hurdles. Additionally, a suggestion for research is to derive effective methods surrounding LGBTQ+ education for parents. Heteronormativity occasionally results from unawareness, yet there is a lack of research addressing how to inform parents to be more inclusive in the household and through media. Considering how to reduce parental heteronormative ideologies would promote a more diverse mediascape at home for a new generation of children.

For references, footnotes and endnotes, click here.

Click here for APPENDIX A - Informed Consent Form

Click here for APPENDIX B - Parent Survey on Children LGBTQ+ Media Exposure

Click here for APPENDIX C - Full Parental Written Responses

Healthcare

The Reign of The Pharmaceutical Corporation

Raj Rajput, *United States*

Raj Rajput, an imaginative and dedicated student from Obra D. Tompkins Highschool, hopes to solve real-world issues such as corruption, pollution, and inequality by raising awareness and presenting well-backed solutions to the future generations.

Abstract

The healthcare industry is a critical component of modern life that many people depend on for their livelihood and health. It is responsible for treating a wide variety of diseases and other health issues to increase life expectancies all around the world. However, with the rising costs of medicine and treatments proposed by pharmaceutical companies, many people are forced to avoid cures due to future financial instability for themselves and their families. This leaves them vulnerable to many health complications and even death in the near future. This study evaluates scientific findings and procedures regarding pharmaceutical regulation cited by the well-known author Ben Goldacre as well as the viewpoints of representatives from both Harvard and Emory University to determine the main issues with the current medical industry. It also recognizes the costs of various treatments and medicines given by large pharmaceutical companies and evaluates their reasonability. The results of the research indicate that pharmaceutical companies have large margins of profit and often hide information from governments, health care professionals, and the general public to ensure their own financial success and strong reputation. These organizations also use many loopholes to further increase their credence and exploit individuals worldwide.

Throughout history, there has always been a need for reliable healthcare. From the establishment of the first American colony of Jamestown in 1607 to the twenty-first-century pandemic known as COVID-19, humans have always relied on medical facilities to keep their families secure, safeguard their earnings, and ensure healthy and sustainable lifestyles. While the priorities of the general consumers haven't changed since the early sixteen-hundreds, the desires

and powers of pharmaceutical corporations have begun to plague the healthcare industry and catalyse the destruction of millions of lives. In order to rekindle the relationship between civilians and the medical industry in today's society, there needs to be large-scale technological, political, and social change to ensure transparency and equality for all people who wish to utilize the healthcare sector.

With the help of modernization and promising innovations, society is more technologically advanced than ever before. However, technology is still neglected in the medical industry, allowing many corporations to exploit medical professionals and patients to garner large profits. The well-renowned author, Ben Goldacre stated that "researchers looked into every trial of psychiatric drugs in four academic journals over a ten-year period" to conclude that industry "sponsors got favourable outcomes for their own drug 78 per cent of the time, while independently-funded trials only gave a positive result in 48 per cent of cases". Through such behaviour, privately owned pharmaceutical companies can generate promising results, allowing them to force their products on to consumers and medical personnel with little consideration for the safety, reliability, or cost of the prescription. Additionally, through this contemporary drug establishment process, which is based solely on paper (journals or notebooks), it is difficult for trusted medical facilities or individuals to challenge or regulate the distribution of new medications. However, Goldacre provides effective solutions to these issues, stating that the major issues within the contemporary pharmaceutical industry can be resolved by placing all "trials [regardless of their outcomes] in electronic health records". By doing so, doctors and medical personnel can access the history of a drug to confirm its validity at any time and drugs can also be properly evaluated for public consumption and distribution. Furthermore, by limiting the influence of pharmaceutical companies, governments and private charities can better negotiate with these pharmaceutical corporations and reduce the cost of prescriptions and treatments for all patients. According to an infographic by Eyeforpharma, almost "8 out of 10 American workers have at least one chronic condition" and "half of those have more than one". Currently, many of the individuals who suffer from medical issues cannot access healthcare because of the financial burden placed upon them and their families. Electronic recording can increase the reliability of new drugs by providing easily accessible empirical data and by reducing costs for patients, making treatment a viable option. In essence, electronic recording, alongside future technological developments, can help increase transparency in the medical industry by balancing the power between pharmaceutical companies and public health officials to create more reliable, accessible healthcare services.

Current trends in the pricing of drugs also indicate that corrective action is necessary within the medical industry for the proper regulation and retail of medication; government involvement in the pharmaceutical industry will only help push society closer to this goal. In his review of the contemporary pharmaceutical industry, Goldacre points to NICE, the UK's National Institute for Health and Clinical Excellence and concludes that even government-based organizations such as "NICE can be given distorted...samples of the data". This reveals the lack of

transparency that defines the interaction between pharmaceutical companies and governments. By involving themselves more directly in negotiations, governments can effectively address crucial issues in the medical industry to reinforce the rights of their citizens and negotiate drug prices without having to worry about interference or hostility from the drug corporations themselves. The current lack of government affiliation also demands a global transmission of ideas. Catherine DeAngelis notes that "legislative bills regarding the pharmaceutical companies' cost of transparency are currently being considered in at least 5 states, including California, Massachusetts, North Carolina, Oregon, and Pennsylvania" within the United States. While this may seem like a meager step toward long term transparency with the pharmaceutical corporations, the initiative has the ability to influence nations around the world, compelling them to act against the corporations that hinder the efficiency of their healthcare systems. Through these actions, countries can create better medical industries, facilitating economic growth, longer life expectancies, and more productive citizens. Lisa Ellis, reaffirms that leaders "need to keep on their radar, staying on top of overall medical care delivery reform in the U.S., and strategies to accomplish this ambitious goal, as well as tracking progress on health insurance for the U.S. population". While government involvement is a priority, the primary goal is for the involvement to address the needs of the citizens to ensure transparency and equality and not to simply keep peace with pharmaceutical corporations.

For many years there has been great conflict about the setting of drug prices (for example the drug "Zolgensma" set at "$2.1 million"). Leslie E. Sekerka and Lauren Benishek from Emory University state that in 2016 "80 prescription drug advertisements were televised every hour, totaling 1,920 drug ads directed at American viewers per day". These statistics alone demonstrate the magnitude of manipulation that pharmaceutical companies invest to attract customers and secure profits. Not only do they create manipulative advertisements that "normalize obscure disorders" and encourage "people to believe they suffer from certain dysfunctions", but they justify the costs associated with these drugs by relying on reputation, exploiting public confidence in drug companies (Sekerka/Benishek 2). Though it may seem difficult to regulate the messaging of pharmaceutical organizations, it can become a reality with the help of various media platforms. For example, through strict regulation, TV broadcasters can enforce rules to ensure that all advertisements on their platform are strictly factual and directed toward a desired audience for a specific professionally diagnosed need. This would prevent the overconsumption of drugs and also keep the actions of drug companies in check. There would be increased transparency for the public, and pharmaceutical companies would be forced to only provide drugs to the individuals who actually need them. Organizations should act in the best interests of its consumers because "life and health are generally foremost among the things considered absolute and infinitely valuable" and social initiative from corporations themselves can help achieve this goal (Huebner 3). Furthermore, the actions of one corporation can influence the actions of other corporations, meaning that morality can easily spread through the industry once the initiative is taken.

After reviewing a composition of reliable data coming from individuals who have done extensive work on the pharmaceutical industry, it can be concluded that millions of lives are lost each year due to opacity in the pharmaceutical industry. Furthermore, pharmaceutical companies leverage powers, such as regulating the prices of life-saving drugs, to exploit both governments and individuals worldwide. However, through the support of citizens and adequate technological, political, and social change, humans can transform their healthcare system into one that guarantees transparency and health for all people.

For references, footnotes and endnotes, click here.

Social Justice

CENSORSHIP: A NECESSITY OR A STIFLING OF FREEDOM?

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In what we classify as the 'Information Age', advancements in technology have incited unease with media, art, and education. The universal solution of censorship is currently being implemented into every aspect of our daily lives. Research in an article by Mette Newth (NO, 2010), states that the concept of censorship was first introduced as early as the year 443 BC in Rome as a method of "shaping the character" of its citizens. But how thoroughly are we able to endorse the concept of censorship? It has the ability to 'protect' us from certain obscenities or profanities butcensorship can be enforced and rationalized so long as "ideas are false or dangerous by the standards of the authorities" (Darity, 2008). So perhaps censors may stand behind facades of virtue, deceiving society or warping our perceptions of what is 'morally correct' in order to obtain "status and control within" it (White, 1997). If definitions of censorship are invariably relativistic, to what extent is it beneficial to modern-day society?

Throughout this report, I will explore the influence of censorship on perspectives in both concrete and constructed realms of society. I consider this within three spheres: Media, Education, and Art. I believe that in these categories, the effects of censorship are strongest

Since 2015, the total number of social media users globally has grown from 2,078 million to 3,960 million, equivalent to an increase of 92.76% within a span of five years. (Dean, 2021) Approximately 95% of the American teenage population is known to have associations with certain media platforms, based on a survey conducted by the Pew Research Center (Anderson & Jiang, 2018). This indicates that teenagers constitute a substantial segment of the entire digital community. Therefore, it may be apparent that the spread of explicit, sexual, and violent content (Khan Academy, n.d.) throughout the internet/media for the years to come, would be a centraln threat to the safety of young internet users. However, it is noticeable that several gaming and media platforms with adolescent users - including Roblox, Disney - have all imposed underage user regulations. These allow for a more child-friendly experience by limiting "inappropriate content"

and exchange of "private information", inhibiting the adverse effects of communication within online platforms.

In the media realm, information acts as the foundation for an individual's political views as the media displays "each party in such a way that it creates an image of each party differently" (Sagheer, 2017). Many argue that the exposure to negativity on the news can lead to violent behaviour, where emotional "desensitization to violence represents a form of habituation" (Mrug & Madan & Windle, 2016). The spread of 'anti-Asian propaganda' exemplified by former-president Trump referring to Covid-19 as the "China virus" & "Wuhan virus" (Aggeler, 2021), sparked an increase of 1,900% in Asian-targeted hate crimes between 2019 to 2020 (Donlevy, 2020). The same statistic increased by 454% in the UK (Metropolitan Police, 2020). Both statistics are alarming as the media has its greatest influence in first-world countries, "empowering the already powerful" (Walden University, N/A).

The news media chooses to censor its visual content, in order to remain informative while preventing the widespread broadcasting of discrimination towards specific parties. According to the Encyclopedia of International Media and Communications, media is "generally barred from publicizing speech that incites ethnic or religious hatred" or promotes the "propaganda of war" (Belin, 2003), implying this correlation between the news media and violence. But we must not shoot the messenger. Causes of news fabrication or censorship do not lie in the news itself, but rather in the source -- state and private influences.

The diverse multitude of sources curated, ranging from 1997 - 2021, provides a significantly more credible and receptive account of the issue at hand.

In far more concrete realms like education, it is a notable issue that conspicuous implementations of censorship in institutions have been applied "throughout history by religious, political, military, and corporate powers" (Evans & Selgelid, 2015), with intentions to prevent contentious "philosophical... political, and legal" issues from evolving into the school system/syllabus (Petosa, 1988). I was even personally restricted from performing a 'ritualistic scene' in my devised drama piece due to my school's censorship of religious and 'objectionable' topics. These restrictions limit the level of power of theatre and performance, compelling me to perceive 'freedom of expression' as an earned luxury rather than in intrinsic right. Censorship has formed a generation "incapable of appreciating the difference between independence of thought and subservience" (Commager, 1954). It has "diminish[ed] students' potential for learning about the risks and benefits of various behaviours" (Petrosa, 1988). In Denmark (Madsen & Verhoeven, 2016), journalists who were presented with possible risks of publication exhibited more caution before announcing/posting media publicly by postponing publications, re-phrasing content, and requesting for second opinions, actively self-censoring in hopes to "retain the quality of communication" as a form of

behavioural adaptation. Truth, like freedom, is here rendered an aspirational object, deprived by those who hold the reigns of censorship.

Now, we are approaching a modern-day society which embraces freedom of expression. After all, Galileo Galilei died for his 'conspiracy' that the sun does not revolve around the Earth (Smith & Torres, 2006). By applying Plato's suggestion that only "models of virtuous thoughts" are fit for our current society, we shrink away from controversial issues by neglecting this enhancement of wisdom and knowledge to the youth at an early age (Hall, 2002). "Intellectual protectionism frustrates rather than enhances young people's mental agility and capacity to deal with the world".

Impressions of art, in the concrete realm, has remained a subject of dispute due to fluctuating standards in what is deemed to be 'artistic'. The line between art and blasphemy is, after all, is anything but exact. Sexual exposure in art & entertainment is most scrutinized by censorship because of the belief that these art forms "lack redeeming social values" and are "offensive/unethical" to society (Mae, 2019). But on the contrary, sexual imagery in art has always been existent throughout history as "elements of [our] predecessor's culture" (Vine, 2017). I have observed displays of sculptures and paintings in digital museums of the Louvre (Paris) or the Acropolis of Athens (Greece) which feature numerous artworks with revealed genitals and body parts. Yet, the experience did not incite any negative response, it actually enabled me to better embrace my human nature, diverting my attention back to a time when clothing wasn't a "subject of focus" on a figure (Yoder, 2012). A lack of clothing may communicate a liberating irrelevance to the rationalizations of good appearances and impressions. It is a reminder that people are allowed to "feel confident in the body they are in" (Young, 2020), as narrowing the scope of 'acceptable' manifestations in appearance would lead to conformity and "the stifling of freedom" (National Art Education Association, 2019).

Furthermore, from an educational perspective, explicit expressions in art can also contribute to a broader interpretation of our history. By maintaining these significances and traditional values in modern society, the new generation may immerse themselves into more intimate perceptions and understandings of the past (Kristen, 2012). Moreover, studies into the influence of modernization and westernization within third-world colonial and post-colonial countries point towards art as the preserver of otherwise endangered or extinguished histories. (Wahab & Odunsi & Ajiboye, 2012)While we cannot ban censorship altogether, we can improve its efficiency in the global outlook, by having censors provide more clarity in the "standards governing the removal of expression" (Citron, 2017).

CONCLUSION

Considering several scopes of interpretation, it is possible that censorship may have been more beneficial in previous times than modern ones. I believe censorship can be imposed more stringently on forms of entertainment as opposed to factual content. Social media has interests which conflict with those of various educational institutions; no user on social media is bound by human decency. In education, by contrast, it is a mentors' job to educate, no matter how gory or obscene. If necessary, this course of action should be taken as what the children are taught, ultimately, becomes the truth. Concisely phrased, information sources that serve an educational or informative purpose (education, news, and art) rather than purely entertainment purposes (gaming or social Media) should have a right of expression. These rights must not be limited by the illusions of censorship.

For references, footnotes and endnotes, click here.

Culture

Witchcraft in Morocco

Sarah Ouardaoui, *United States and Morocco*

Sarah Ouardaoui, 15 years old, currently in her junior year of high school. Passionate about STEM, social phenomena, and painting.

The wide-ranging and often opposing imaginings of witchcraft depend on its social and cultural context. In fact, each and every society has its own perceptions of traditions, beliefs, religions, rites, connections to the afterlife and interpretations of death, so much so that it's quite literally unfeasible to assess a concise understanding of witchcraft.

The word itself refers to the practice of a certain form of magic, in which the wizard works with supernatural forces, evil entities (or good ones), and natural forces such as those of plants, lunar cycles, wavelengths, and crystals, to cast spells and perform magical rituals. Still, depending on the spatio-temporal context, sorcery has been viewed with varying degrees of favor, hostility, and sometimes ambivalence. Indeed the world is noticing today a rise in occult practices caused by a renewed interest in astrology and horoscopes, especially in the younger generation heavily influenced by the positive light in which modern day wizards are painted. For instance, you need only to take a quick glance at the very popular social media app "TikTok" to notice a thriving community of witches that feed off educating their viewers about what they byname as "Magick ". And yet, just some centuries ago, Salem witch trials (1692-1693) were in full swing – a series of gruesome executions that condemned alleged witches of evil crimes. Their condemnation stemmed from the conservative Puritan secular leaders of Massachusetts. The Salem massacre was just one of the thousands of grizzly and horrid slaughters that took place during 3 centuries all across Europe, America, Asia and Africa.

In this article, I am going to examine the current state of witchcraft in Morocco - geographically, the closest African country to Europe.

Witchcraft is an established social and cultural reality across the whole African continent. Sorcery rites are present in every corner, from urban to rural societies. Faith in them is widespread. Today, the central question is not the verity of these claims, as they foist themselves into private and public places regardless, but rather how we respond to this reality. Despite accelerating urbanisation, expanding education systems and religions such as Islam and Christianity, all of which violently rebuke this practice, witchcraft remains tenaciously implanted in Moroccan mentalities and traditions.

In Morocco, children are slaughtered by sorcerers if -as ill luck would have it- they have distinctive signs in their hands, while simultaneously having strabismus, a medical condition commonly known as crossed eyes. The popular belief that sacrificing these children and delivering their blood as a hecatomb to demons will help wizards find a hidden treasure drives, perpetuates and sustains this first degree manslaughter.

Some people prefer to choose a clairvoyant session over a therapy session by a certified psychologist. It is claimed that all problems of any nature, even the rarest and the most peculiar ones, can be “solved" by touch of witchcraft.

A very old tradition in Morocco, which emanates from Berber, Arab and Jewish beliefs, stipulates that all African heads of state should have their own personal wizards or occult advisers. Indeed, this was the case for the late King Hassan II (governing Morocco from 1961 to 1999) who would allegedly regularly consult local seers. Sources say that he would sometimes make them come all the way from the High Atlas Mountains for predictions. These claims originate in the book "The King's Fool" written by author and painter Mahi Binebine, who is none other than the son of the late sovereign's storyteller.

Next I will discuss a more detailed inspection of the consequences of this phenomenon, in particular: the perception of Moroccan women as witches by the rest of the world.

This tenacious cliché, proclaimed in a good portion of Arab countries, claims that Morocco is a place brimming with black magic, and that its women are wicked witches, home-wreckers (or husband stealers) and bewitchers- in its most magical and hypnotic definition. Hence, it is believed that by exploiting their charms and evil potions, they would lure helpless men into their ambush.

However the reality is that there are also many men who practice wizardry in Morocco. That the damnation and blame is placed solely on women can only be explained by pervasive misogyny. In addition, it’s a widespread belief that occult practices are generally used to cause disunity in a family and separate the spouses.Indeed, according to patriarchal forces, such disunity can only be accomplished by a woman because she will always remain vicious, venal, and depraved no matter what. This stereotype has given rise to a wave of discrimination, subjugation and oppression which ranges from insults, judgments and teasing to physical threats towards Moroccan women abroad, and especially in France, where the North African community is massive, and in countries of the Arabian Peninsula.

The ubiquitous witchcraft practices in Morocco stem from the mingling of Arab, Berber, Jewish, and African cultures, resulting in horrendous crimes, and a tarnished image of the country’s female population. So my question is today: Is it actually possible for Moroccans to leave behind these ancient customs or is it really an essential part of their identity?

For references, footnotes and endnotes, click here.

Social Justice

The US economy's recovery from COVID-19: Are demand-side policies the most effective method of increasing the level of national income/economic activity?

Dishaan R Pandey, *India*

Dishaan is a Junior at Indus International School in Bangalore, India. He is very passionate about economics, and his paper is on the use of demand-side policies to aid the US economy's recovery post the coronavirus pandemic.

Abstract

Studying the COVID-19 pandemic, the United States economy's recovery has been a lot faster compared to the 2007 crash. This is because this time, the government spent a lot more on the demand side. This stimulus package put money in the average American's hands and allowed them to spend this disposable income. The American government realized the importance of putting money in the citizens' hands after the first economic crash. This increase in aggregate demand due to the stimulus package increased the GNI of the country significantly.

Introduction

Demand-side policies focus on changing aggregate demand to achieve price stability goals, full employment, and economic growth. The gross national income measures the income earned by the country's residents, regardless of where the income comes from. GNI is equal to the value of the final goods and services produced in the country, including net exports. There are two types of demand-side policies; the first is the fiscal policies, and the second is the monetary policy. The government is in charge of the fiscal policy, and the central bank is in charge of the monetary policy. Expansionary fiscal and monetary policies can stimulate the economy and grow the national income

of a country very effectively. That being said, the government and the central bank need to ensure that these policies' implementation has the most effective results by timing them correctly.

Fiscal policy refers to changes made in the tax levels and the government expenditure to influence aggregate demand in the economy. For instance, if a government wants to stimulate the economic growth, they can reduce the taxation levels in the economy, this will lower the production cost for producers in the economy and allow them to supply more goods and services at lower prices, this will incentivize the consumers in the economy to increase aggregate demand and in turn, increase the national income. Similarly, the government can also use transfer payments and subsidies to stimulate the economy and improve the aggregate demand in the economy. These measures come under the expansionary policy; that being said, the government can also implement contractionary policies in order to reduce economic growth and slow down the economy to tackle inflation.

Methods of increasing national income and GDP

One of the most effective ways the government can increase national income is by increasing education and health care expenditure; this ensures that there is more economic activity and more innovation in the future generations. Another measure that the government can take is subsidies; governments can give subsidies to businesses in the economy; this will lower their costs and encourage them to produce more. Subsidizing industries will also increase the number of jobs in the economy, increasing national income as there would be a fall in the natural rate of unemployment.

Monetary policies are managed by the central bank and play a crucial role in the economic activity of a country. The central bank can control the economy's interest rates and influence the aggregate demand in the economy. The central bank also controls regulations that the commercial banks in the economy have to adhere to. For example, if the central bank decides to reduce the interest rates, borrowing in the economy is less expensive and encourages more businesses and individuals to borrow. By cheaper borrowing, more firms can borrow and grow; this will increase the national income in the economy significantly as more jobs will be created. The central bank also controls the amount that commercial banks have to keep in reserves. By lowering the amount that commercial banks have to keep in reserves, the central bank allows the commercial banks to lend more to the economy and stimulate economic growth.

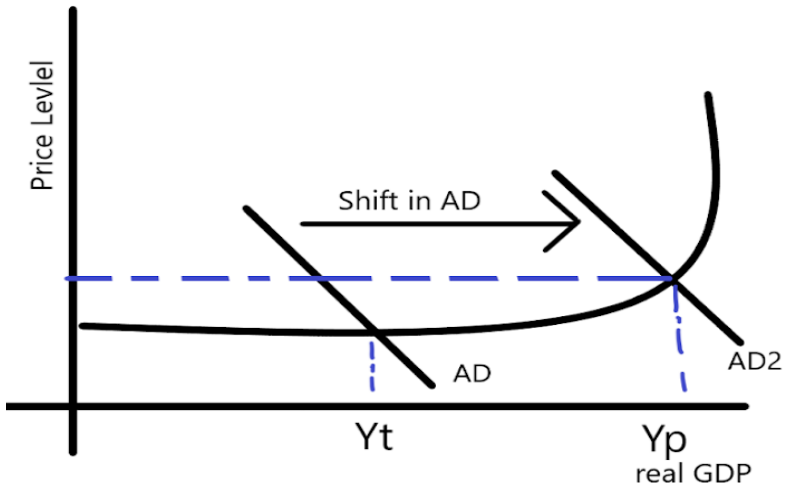

Figure 1.1

The diagram (Keynesian) above shows the possible shift in aggregate demand stimulated by expansionary fiscal and monetary policy. The demand curve shifts from AD to AD2, and the real GDP/GNI value shifts from Yt to Yp. This can be due to lower taxes or lower interest rates.

Comparing the economic crash of 2007 to COVID-19

If we analyze the 2007-8 global economic crash, we realize that the United States government used various demand-side policies to ensure the economy recovers after the crash. One of the crucial measures that the US government took was to reduce taxes, whether income tax or sales tax. This was in order to increase the disposable income that was available to the consumers in the economy. This increase in disposable income allowed people to increase expenditure in the economy. America's central bank also lowered interest rates (but obviously increase borrowing regulation as the crash was caused by the lack of regulation) so that businesses could get back on their feet and start producing goods and services in the economy again. The government also bailed out many large corporations and firms (especially on wall street) as the united states' economy relied heavily upon them. These large corporations that were bailed out after the economic crash built the foundations of the USA economy.

That being said, the demand-side policies implemented by the government at the time did have strengths and weaknesses. The power of implementing the fiscal policy post the global economic crash includes pulling an economy out of a recession where people lost jobs and lost their homes. That being said, the government and monetary policies implemented only started to show effect post-2012. This is the time lag problem, demand-side policies (especially fiscal) are often subject to

the time lag, and the policies take a long time to work. This is why it took the United States around five years to deal with the 2008 crash. If we look at the tax cuts that the US government implemented, we realize that they were not very effective; this is because people in the economy ended up saving the extra disposable income they now had. This was also a leakage. People started saving due to the lack of confidence in the economy. Millions of people in the US also lost jobs after the economic crash, and due to this, the government expenditure was a lot more effective than the reduction in income tax rates.

If we look at the COVID-19 pandemic, the United States economy's recovery has been a lot faster compared to the 2007 crash. This is because this time, the government spent a lot more on the demand side. This stimulus package put money in the average American's hands and allowed them to spend this disposable income. The American government realized the importance of putting money in the citizens' hands after the first economic crash. This increase in aggregate demand due to the stimulus package increased the GNI of the country significantly.

If we look at the United States of America stimulus package, their package focused on the supply side policies and had great focus on the demand side policies; the entire amount provided to the USA citizens was also allocated more efficiently. On March 27th, President Donald Trump signed a stimulus package that includes direct payments up to $1200 for American Citizens, loans for small businesses to forestall laying off employees, and brace the unemployment insurance. The provision of $1200 allowed people to increase their demand in the economy; this helped the producers sustain their businesses and survive independently. The $1200 given to the adults and $500 given to children allowed people to consume their essentials, especially for the people living per paycheck. For the people who lost their jobs, the money provided to them by the government allowed them to allocate it in places they saw fit. Many people also started investing in the United States financial markets after the amount provided to them by the united states government. Overall, the USA's recovery has been more effective due to the expenditure on demand-side policies and more effective allocation of the stimulus package. Donald Trump also proposed giving another $300 billion as a package to the American people; this clearly shows that the American government believes that the demand-side policies are just as crucial as the supply-side policies, if not more important.

Why do the demand-side policies work?

"The fundamental psychological law, upon which we are entitled to depend with great confidence both a priori from our knowledge of human nature and from the detailed facts of experience, is that men are disposed, as a rule, and on the average, to increase their consumption as their income increases, but not by as much as the increase in their income."[1]

John Maynard Keynes suggested a positive relationship between the disposable income of a householder and consumption. Keynes hypothesized that the change in consumption for every unit of change in income is lesser than 1 and greater than 0. This infers that for every 1 unit of increase in disposable income, there will be an increase in consumption by more than 0, but lesser than 1 unit. This is the economic concept of marginal propensity of consumption. In economics, the marginal propensity to consume (MPC) is defined as the proportion of an aggregate raise in pay that a consumer spends on the consumption of goods and services, as opposed to saving it.[2]

The Keynes theory of consumption essentially states that as disposable income increases, the quantity demanded by the consumer in the economy also increases. Therefore, a reduction in income taxes, in theory should lead to an increase in aggregate demand in the economy. That being said, in the case of inferior goods consumer demand and income are inversely proportional. A government needs to evaluate the kind of goods being produced in an economy and accordingly implement policies that correct the market failures and lead to the most efficient allocation of resources.

The central bank in an economy is responsible for implementing the monetary policy. The monetary policy includes changing the interest rates in the economy to manipulate aggregate demand and various other factors of the economy. The central bank controls the money supply of the economy and can control the interest rates. Interest rates are a portion of the principle paid to lenders by householders and firms in the economy as a payment for borrowing capital. Higher interest rates in the economy make borrowing more expensive and this disincentivizes consumers to borrow, higher interest rates also encourage people to save money and this is counted as a leakage in the economy. On the contrary, lower interest rates allow people to borrow more at lower costs, this promotes demand in the economy and overall economic growth.

For references, footnotes and endnotes, click here.

Acknowledgements

Ms Maya Girish Nagappa, Harvard M.Ed.

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Economics

Effects and Solutions of Economic Inequality

Taehyun Sa, *South Korea/Canada*

Taehyun Sa, student-journalist, social equality activist, and student at the Earl of March Secondary School.

Abstract

The purpose of this research was to investigate both the direct and indirect consequences caused by economic inequality and income inequality, as well as a solution to this worsening issue. It discusses how economic inequality promotes an increase in poverty and the shrinking of the middle class, which indirectly establishes highly competitive job markets and education systems. This research further investigates how competitive job markets and education systems produced by economic inequality act as a leading factor for adolescent suicide rates. In addition to the aforementioned consequences of economic disparity, it also introduces a new solution to economic inequality, which not only addresses economic inequality in general, but also reduces racial segregation and the black-white wealth gap in the United States. This new solution is the abolishment of school boundaries and a new nationwide educational funding system, where all schools receive equal educational funding, regardless of their geography. Interestingly, urban planning, school segregation, and unequal school funding is what reinforces the black-white wealth gap and is also a key determinant of economic inequality.

Introduction

The World Social Report 2020[1], released by the United Nations Department of Economic and Social Affairs, demonstrates the consequences of economic disparity and identifies flawed political systems that often favour the wealthy as its driver. Economic inequality thus becomes a self-reinforcing cycle that grows to the extremes where poverty is simply atrocious and where basic human rights such as healthcare are only accessible to the wealthy upper-class households. Not only can it exacerbate extreme poverty and further divide society by shrinking the middle class, it also causes unemployment to skyrocket. In such cases, the report argues how there is a high likelihood that the middle class will no longer exist; in fact, the middle class is already diminishing at a constant rate every year[2] due to technological advancements disrupting traditional industries.

The Consequences & The Job Market

Consequently, it has become arduous, as some may say, for the majority of people to obtain a stable job in today's society. While the global population, and thus the need for jobs, is growing at an alarming rate, technology has already taken over 90% of the jobs humans used to do in the past[3], meaning that in the near future, with so many people here on earth[4] and with the rate at

which technology makes human jobs obsolete, it will be extraordinarily hard for most people to acquire a stable, well-paying career. According to the World Economic Forum, automation and technology will be able to support 85 million jobs by 2025, and will continue to do so.[5] For instance, according to Forbes,[6] seventy years ago, a little over 3% of the U.S. workforce was employed by the railroad industry, however, today, only 0.1% of the workforce is involved, but the U.S. still manages to move nearly three times the amount of freight around the country.[7] Another example is the agricultural industry. Prior to the early 20th century, the vast majority of the world population worked on farms. Nowadays, however, the invention and proliferation of technology has made it possible for a small minority of farmers to provide food for over seven billion of us. In fact, one single farm in the United States is able to provide food annually for 166 people living in both the U.S. and abroad.[8] Therefore, it is evident that while lower-income jobs are getting replaced by technology at a constant rate, middle-income and higher-income jobs, which are and will become the only type of jobs available given the current rate of proliferation of technology, are further getting challenged by the amount of competition that many of the younger generations are bound to face.

Due to this rising competition for employment, vanishing lower-income jobs, and thus a rapidly-growing, highly-skilled workforce unable to attain the jobs they want, getting a job in today's world has become concerningly difficult.[9,10] As a result of the aforementioned reasons, global competition and technology are destroying middle-class professions and strong skill sets are no longer sufficient for well paying jobs. According to Market Watch[11], 'Middle-skill workers are now more likely to be in the lower-income class and less likely to be middle income. Highly skilled workers are also less likely to make it to the higher-income class.'

Education In Hyper-Competitive Societies Caused By Economic Inequality

A lack of access to safe and reliable education is harmful to our society and widens economic inequality. Besides the competitiveness it is bringing to our society, it is also a culprit for the intense academic pressure in our society. Consider the 2018 PISA (*Programme for International Student Assessment*) results.[12] The top five countries are China, Singapore, Japan, South Korea, and Estonia. As you may have noticed, four out of the five nations mentioned are all east Asian nations, yet all of these nations have one thing in common; a hyper-competitive education system.[13] While these nations are frequently championed as successful education systems, their success comes at an immense societal cost. First, consider South Korea's education system, the country with the highest suicide rate out of these nations[14], where suicide caused by academic pressure remains one of the leading cause of death for adolescents.[15] As a matter of fact, students, from the age of five, start attending hagwons, after-school education programs where children learn to improve their test scores in a variety of school subjects from mathematics to English literature. There are more than 100,000[16] of these hagwons, located all over South Korea, not made for students who wish to keep up with the regular school curriculum, but for students who wish to learn subjects that are two, or even three grades higher than their current level of

education. This is why hagwons and other forms of tutoring are referred to as a multi-billion dollar business in both the South Korean and Asian economies more generally.

More than 95%[17] of all students attend these after-school programs for several hours after regular school finishes. In addition to one-on-one tutoring. In total, average South Korean students study up to 16 -hours a day[18] or more[19], learning a variety of advanced subjects. All of this preparation is to ensure that they succeed in their Suneung exam, the South Korean tertiary entrance test that quite literally defines a person's life in the South Korean society.[20] On this day, no single shop is open, no flights depart or land, and where all construction projects cease to ensure that every student can reach their fullest potential.[21]

For the aforementioned reasons, South Korea, along with many other east-Asian nations such as Japan, China, and Singapore, has one of the highest teen suicide levels.[22] The same situation can be seen in other East Asian nations[23], which out-rank other nations, in tests of academic ability. As a consequence of this hyper-competitive society, students often resort to cheating and wealthier parents resort to back-door dealings with universities through bribery. In the United States alone, a total of 50 people have been charged for university bribery,[24] just in one year. This number includes 33 parents of college applicants[25] and 11 named collegiate coaches or athletic administrators[26] from eight prestigious universities. According to the New York Times,[27] federal authorities say dozens of actresses, business leaders and other wealthy parents were involved in a nationwide bribery and fraud scheme to aid students in gaining admission to most elite universities.

All that being said, I have not answered how academic pressure is necessarily caused by economic inequality, as well as its relevance to the topic. However, in order to answer this question, we must first recall that manual labour is increasingly replaced by technology. Due to this highly competitive job market, people generally need higher education and more diverse experiences to obtain average middle-class jobs. In order to obtain higher education and more diverse experiences, high academic achievements are needed even from high school students, which thus causes burdensome academic pressure among parents and students.

Expert Interview

In order to provide some additional evidence to support my claims, here is an interview with Miran Hwang, a South Korean citizen who has worked in the hagwon industry for more than a decade.

<u>Question 1: What is the daily life of an average South Korean student?</u>

'As for kindergarten students, they finish kindergarten at three o'clock and are further introduced to a variety of after-school education including English, piano, art, and taekwondo. Only by 6 o'clock do they finish their extracurricular activities. As for intermediate and secondary students, they are faced with a variety of after-school tutoring and hagwon courses that cover everything from literature to mathematics.'

'In fact, it is only until 10 in the evening when they have finished all of their extracurricular activities and it is only by 1 or 2 o'clock in the morning when these students have finally finished all of their assignments.'

Question 2: Why is the education system so competitive?

'The main reason why education is so competitive here is because of the fact that while the population of our country is growing, the size of our country remains small, which means that there are close to zero natural resources. Hence, the only reason South Korea could become a developed country after its war-torn past was all thanks to education and in order to remain this way, educating our future generation is the best possible method. In addition, in Asian culture, going to a university is not a choice, it is a requirement and it is no exception in South Korean society. For this reason, more than 70% of all South Koreans have received tertiary education.'

'When applying for a job, for instance, the first thing the interviewers will look at is the name of the university you have graduated from and whether you have graduated from a university in Seoul, or a university elsewhere.'

'However, nowadays even if you graduated from one of the SKY universities (an acronym to represent the most prestigious universities in South Korea), many people still struggle to get employed in the harsh realities of a shrinking middle-class and the realities where the job market is shrinking at an alarming rate.'

Question 3: What was it like when you were attending school in Korea?

'In our generation, it was much easier to get employed and as long as we performed well on academic tests, it was possible to go to a prestigious university and to further get a well-paying position in a large company. However, nowadays, it is no longer the case. Not only are tests require more critical thinking and are more practical, but participating in volunteering activities, apprenticeships, internships, exchange programs are all also required as prerequisites to get accepted into a university, in addition to all the extra learning they are doing in hagwons.'

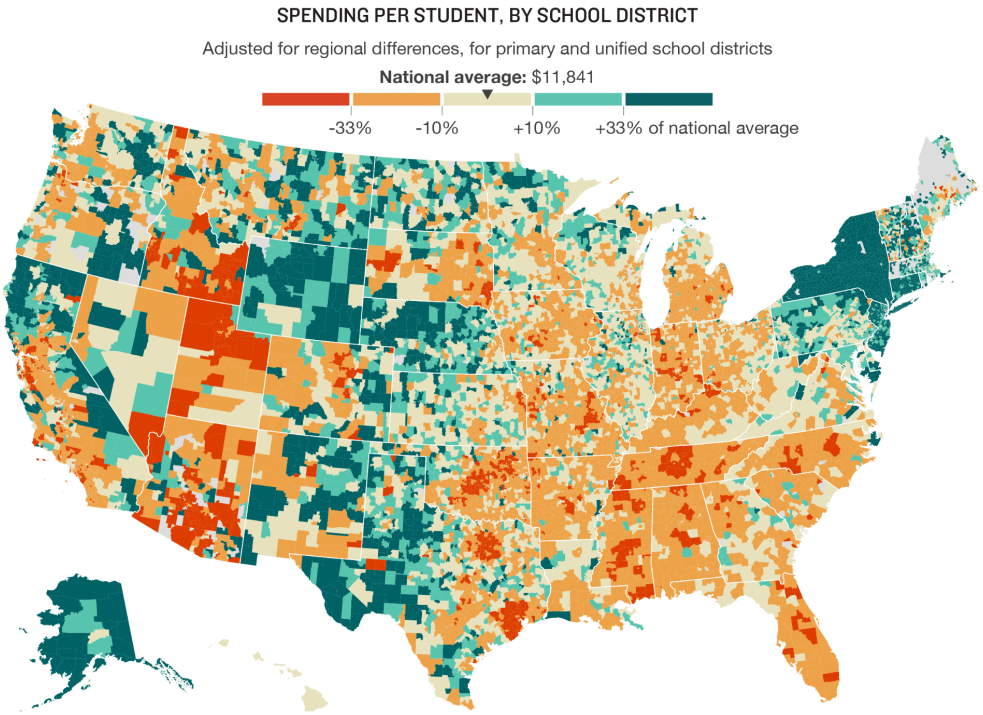
'Further, in order to get a quality apprenticeship, exchange student, or a quality volunteering experience, both connections and wealth are needed, which further makes economic inequality more relevant in society. When we were younger, it seemed like everyone had a job, regardless of their academic background.'

'However, nowadays, when I turn on a Korean news broadcast or when I talk with my relatives, even those who were accepted into some of the nation's most elite universities seem to be struggling to seek a stable job and are often working as part-timers. For instance, one day, when I was watching the news, I was shocked by the headline that the ratio between the people who were accepted and the people who were rejected to become a public servant in South Korea was quite literally 1:70.'

'I mean, when we were young, companies such as Samsung, LG, Hyundai, etc. used to hire hundreds of people every year around March, but now, companies only hire one or two positions every now and then; it has honestly become crazy, and that's really all I can really say.'

Solution

All things considered, the following is a proposal for a solution to solve this increasingly concerning problem. It requires the abolition of school boundaries, the abolition of a system in which property taxes cover the majority of school funding as well as a new federal nationwide educational funding system, where all schools receive equal educational funding. In order to terminate economic inequality, we must first solve the issue of school segregation[28], as it plays a major role in the division of society when it comes to wealth, making some parts of the city wealthy and placing others into literal poverty. The use of property taxes to fund schools[29] creates a self-reinforcing cycle where schools (and other academic institutions) in higher-income neighbourhoods regularly receive significantly more educational funding and parent fundraising compared to lower-income neighbourhoods.[30] Therefore, they are able to attract more and more higher-income families. For instance, according to the Washington Post[31], in countries with rampant economic inequality such as the United States of America, 'an average of 15 percent less per pupil is spent in low-income school districts'. Moreover, studies conducted by the *United States Census Bureau*[32] have found that while lower-income states such as Utah spend USD 5,708 per student, higher-income states such as New York or Massachusetts spend nearly four times more. To clearly demonstrate the differences in educational funding between higher-income and lower-income states, below is a map of spending per student, by each school district in the United States. Some states receive 33% more funding compared to the national average.



33

When students finally graduate, students in higher-income neighbourhoods who were exposed to a wider variety of opportunities, experiences, extracurricular activities, as well as highly-experienced educators and faculty members have a significantly higher chance of receiving tertiary education and later acquiring a stable career. By abolishing school boundaries, students have increased opportunities to socialize with people from a variety of cultural, racial, and religious backgrounds, which, in turn, enables students to better understand others with compassion, and empathy for different kinds of people.

The Relationship Between Racial Segregation & Economic Inequality

It has been almost sixty-seven years since the landmark 1954 Brown vs Board of Education Supreme Court judgment that outlawed racial segregation in the United States. However, the fight for equality is not yet over, as it confronts the continued effects of segregation in the present day.. For instance, in *Block Highschool* located in Catahoula Parish in Louisiana, one of the poorest parishes, uncertified teachers are teaching multiple subjects. Jonesville, where Block high school is located, is one of the poorest parts of Catahoula Parish. Nearly 70% of seniors are black and approximately 60% of the students do not go on to college after graduation. However, approximately 13 miles from Jonesville, in the same school district, there is another high school with noticeable differences. Here, nearly 90% of the senior class are white and they perform better academically and enroll in college at a much higher rate.[34] According to *Now This News,*[35] there is a clear, notable difference in the appearance and the atmosphere of the two schools.

Dr. Belinda Davis, a public policy professor in education at Louisiana State University commented on the unfortunate fact that many schools continue to be economically segregated and that the entire school board at Catahoula Parish should be ashamed that they have a school in that district that is in 'that kind of shape'. Furthermore, according to Tomiko Bloodsaw, a *Block High School* graduate who works as an accountant at a local sheriff's office, the school district budget demonstrates the unequal educational opportunities in Catahoula Parish; in Harrisburg, one school receives $20,000 CAD whereas, in Jonesville, Block highschool only receives approximately $7000 CAD, per year.

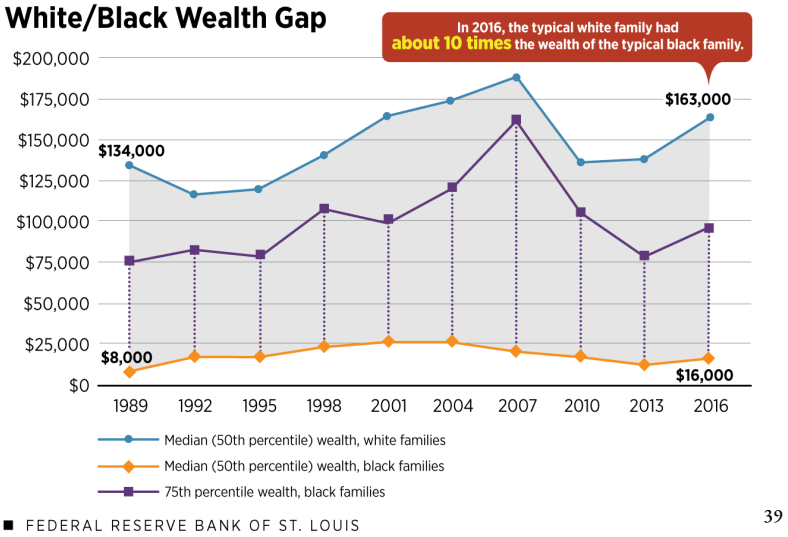
This issue is not only relevant in Catahoula Parish; multiple high schools in rural areas located in the southern United States have also been experiencing modern-day segregation. The following statement comes from a 2014 report by researcher John Kucsera from the University of California, Los Angeles: 'New York has the most segregated schools in the country: in 2009, black and Latino students in the state had the highest concentration in intensely-segregated public schools (less than 10% white enrollment), the lowest exposure to white students, and the most uneven distribution with white students across schools. Heavily impacting these state rankings is New York City, home to the largest and one of the most segregated public school systems in the nation.'

The situation has now deteriorated to an extent where the United States is unofficially segregated. According to Ricard Rothstein, a researcher at the *Economic Policy Institute*, 'The

school's black children attend today, in North and South, East and West, are segregated mostly because their schools are located in segregated neighbourhoods.'

While it is undeniable that racially segregated schools have been on the rise, it does not quite answer the key question; how are racially segregated schools and racially segregated communities caused by economic inequality? School boundaries are the answer. According to *American Apartheid: Segregation and the Making of the Underclass*[36], 'In both Northern and Southern cities, levels of black-white segregation increased dramatically from 1860 to 1940 and have remained strikingly stable since then.'

Racial Residential Segregation: A Fundamental Cause of Racial Disparities in Health[37] mentions that 'segregation is a key determinant of racial differences in socioeconomic mobility and, additionally, can create social and physical risks in residential environments.' Even more strikingly, according to UC Berkeley's *Other & Belonging Institute*, only 2, or 0.017% of cities in the U.S. are classified as 'integrated' when it comes to residential and racial integration.[38]



39

Not only has racial segregation in residential neighbourhoods and communities remained strikingly stable, the black-white wealth gap has also not changed significantly. In 2016, a typical white family had about ten times the wealth of a typical black family, according to the *Federal Reserve Bank of St. Louis*. As a matter of fact, according to another source, *Center for Global Policy Solutions*, 'The median wealth of White households is 16 times that of African American households and 14 times that of Latino households.'[40]

All of this suggests that the black-white segregation in residential neighbourhoods has remained stable alongside the white/black income gap. This considerable income gap that continues to this day is due to school segregation in neighbourhoods where the majority of African Americans (and other ethnic/racial groups) are located. These schools are not afforded the same financial support or educational opportunities offered in other school districts with higher incomes and higher-concentration of the white population. As I mentioned previously, as a result of using property taxes to fund schools, this becomes a self-reinforcing cycle where schools located in

higher-income neighbourhoods receive significantly more educational funding and parent fundraising compared to lower-income neighbourhoods. Since many African Americans live in segregated neighbourhoods with significantly lower incomes, public school funding is significantly lower, compared to more affluent neighbourhoods.

Interviews With Educational Experts

During this research, I have conducted an online survey with several educational faculty members at the *Ottawa Carleton District School Board* (OCDSB). While some took nearly thirteen years to acquire a full-time contract and some felt disrespected daily due to her low wages, all mentioned how economic inequality is a vicious cycle, how higher-income neighbourhoods receive more funding, and how schools in lower-income neighbourhoods gradually cycle down. Here are some replies to the questions provided in the survey (full list of replies at the appendix):

1. How do you feel about economic inequality?

'I feel like economic inequality is a huge issue. This question probably requires a few hours to scratch the surface. People born into wealth have so many systemic advantages and tend to extend that gap each generation. It is not a level playing field in so many ways; access to education, schools in poorer neighbourhoods have less parent fundraising and therefore, as a result, those schools don't have the same advantages.'

'Our school board did a study last year on this disparity. In the US schools are funded based on the standard test results and this becomes a downward cycle since poorest areas can't equip schools with the best technology and or supplies, and since the best teachers go elsewhere for higher salary or for better working conditions. So, the schools gradually cycle down. Access to post secondary or the need to take out huge loans puts some people at a disadvantage and they start their life already behind.'

'For instance, the vaccine roll out in Toronto went disproportionately to richer neighbourhoods, partly because the working class people couldn't access the daily clinics because they don't have the ability to miss work or can't afford the day off. Jeff Bezos has more money than he can spend in a lifetime but his employees work in substandard conditions, limited benefits and in many cases, a below cost of living wage.'

'Lack of economic power leads to some groups being silenced in the media and in the government and others with wealth having more than their share of influence and access to the decision making process. If you don't have the money your life is a much harder struggle than it should be.'

2. Have you ever felt or dealt with economic inequality in your life? If so, what happened? How did you feel?

'I have felt undervalued in my life before. When I was younger and was working in my 1st job I was making minimum wage ($6.85/hr) which was barely enough to purchase anything. I felt disrespected daily due to my wages.'

'Yes, I had to borrow money to attend University and started my career in debt, so, I took a job in a remote community under bad conditions in order to pay off my debts. I worked jobs throughout my schooling and as a result had less time to spend on school, lowered my grades and overall made things more challenging. No car, had to use public transit, and used the food bank all summer. I felt like I was swimming uphill all the time trying to make it and loss of pride or self esteem at times.'

3. How competitive is the job market nowadays?

'Today's job market is more competitive than ever before. However, I still feel like if you are willing to work hard you will get noticed.'

'Very.'

'Very competitive; it took me 13 years to get a full time teaching contract.'

4. Is the job market getting more or less competitive? Please explain why or why not.

'I feel it's more competitive than when I was in the job market after university. People need higher education, more qualifications, and more diverse experiences to be considered for careers and jobs where previously you needed only a degree in a related area.'

'More competitive - people are coming in with more degrees and are competing for the same jobs that people with less education are also applying for.'

Conclusion

Economic inequality is an indirect cause for many of the largest social issues today. School segregation being key to these problems, a new nationwide education funding system is the first step in ensuring that each and every student begins at the same starting point and is able to receive the same quality of education, regardless of where they are situated, gender, race, ethnicity, or income. By introducing this new educational funding system and abolishing school boundaries, all children are able to receive the same educational opportunities and ensure that children born into lower-income families are able to achieve class mobility with quality education and adequately compete with those from higher-income families in the job market, hence eliminating the black/white wealth gap often caused by white-concentrated residential areas enjoying prestige in education due to their higher incomes. Economic inequality also contributes to the shrinking middle class and produces an unemployment crisis, which thus fuels intense employment and academic competition. As Plutarch said, 'an imbalance between the rich and the poor is the oldest and most fatal ailment of all republics. We must not forget this crucial flaw of capitalism and seek to fight for a more equal society where even if income inequality continues to

exist in the near future, our children may at least receive equal educational opportunities to fight against it.

For references, footnotes and endnotes, click here.

Social Justice

Youth Radicalism in Russian Society

Ekaterina Nizovtseva, *Russia*

Ekaterina Nizovtseva is an 11th-grade student from Russia. She is particularly interested in studying politics and sociology.

Youth political movements have two major roles. On one hand, they involve young people in politics, thereby providing an opportunity to acquire the necessary skills outside of a fiercely competitive environment. On the other hand, they are socio-political organizations with a motivated membership who are politically engaged.[1]

Despite the scientific interest in various issues and aspects of youth associations, there is a pressing question about the role of youth in the current politics of the Russian Federation which remains unanswered.

The purpose of this research is to study youth radicalism as an organizational and ideological direction of the youth environment, focused on the confrontation of youth with society and the state and the use of youth energy to introduce chaos and disorder into socio-political consensus.

Young people going through the "growing up" stage, undergo the formation of a personality, and the assimilation of knowledge, social values, and norms necessary to become full-fledged members of society.[2]

Adolescence has several features that distinguish it from other ages. By its nature, youth is a transitional, "suspended" state between childhood and adulthood. In some matters, young people are quite mature, serious, and responsible, and in others, naive, limited, and infantile. This duality defines some contradictions and problems particular to this age.

The problems facing Russian youth relate to the problems facing Russian society more generally. The future of the country is determined not only by the success of the authorities' political work but also by the political activity of young people. In Russia, according to the data of state bodies, only 7% of young people are interested in politics. The vast majority of them are members of official youth structures. 24% of young Russians who are politically active are seriously involved in political radicalism.[3] Distrust and rejection of forms of legal and legitimate political participation are prerequisites for catalysing social and political disintegration. This

provides no space for either political evolution, or the democratisation of public life, and the formation of young people's ideas about politics. That is why analysis of the prospects for the development of youth radicalism in Russia is particularly important compared with youth radicalism in Western countries.

Young people experience disillusionment with the model of "adult" politics imposed on them by real or imagined pressures. Radicals attract young people with their devotion to ideals, contempt for political compromise. It is not the political goal that is important to them, but the process of the movement itself, the fact that alternative political currents are maturing in their ranks.

Radical political practices, whose worldviews do not correspond to generally accepted norms, general anti-establishment sentiments. They contribute to destabilization, the loss of stability from political life and contain the potential for political risks to the Russian government.

Youth radicalism relies on weighty ideological and moral arguments, and claims to be an innovative force capable of shaking up the political and social routine. Youth radicalism inspires trends in the public consciousness, clearly capturing the social mood.

It is easy to attract young people to radical ideas since young people do not yet have stable social positions and interests. Political radicals use the social energy of young people, which can give positive results. There is a growing potential among young people to protest against the existing situation. They have a desire to build a more perfect world.

There is a contradiction between what young people expect from politics and the opportunities provided to them by political organizations.

There are three understandings of youth radicalism in Russian sociological thought:

The first emerges from the fact that young people in Russian society are in a group of social risk. In modern Russia, there is no clear state policy that would promote the cohesion of young people in society and direct their social potential to the public good;

The second emerges from the fact that Russian youth, as a subject of social reproduction, are not sufficiently included in social processes. For example, Russian youth is a social group removed from political life, and its potential is neglected;

The third asserts that youth radicalism is associated with the peculiarities of the youth subculture. Youth subcultures are characterized by an innovative element, which corresponds to world views and systems of value.. Radicalism "grows" from the desire of young people to get ahead of reality, from discrepancies between values and generally accepted rules in the public environment.

It is necessary to comprehend youth radicalism as a systematic phenomenon caused by socio-psychological features in the development and socialization of youth, as well as processes in the economic, political, and social spheres of Russia. The specifics of youth consciousness and radical traditions in Russia. Under unfavorable socio-economic and political conditions, youth radicalism is realized in nihilism, sharp mood fluctuations and extreme actions justified by social and political goals.

The majority of Russian youth hold conflicting attitudes towards radicalism. On one hand, there is no willingness to take part in radical actions at the personal level. On the other hand, there is indifference or warmth towards youth radicalism as a justified reaction of young people to dissatisfaction with their position in socio-political life.[4]

Young people tend to think about radical actions with a sense of distance. Unlike threats from the bureaucracy and the criminal world, young people do not see radicalism as a threat to their immediate interests.

Radicalism can be segmented into three categories:

Firstly, radicalism is associated with the tradition of individualism and the desire to be "the master of oneself" -- demonstrating one's independence by going beyond the social standard;

Secondly, radicalism is focused on the desire to be recognized and arouse respect among young people. It is based on an extreme form of self-expression;

Thirdly, radicalism is associated with the disbelief among young people towards the codes of social and legal self-regulation, the value of law, and social solidarity.

Youth radicalism claims both to reject organizational structures and be a new social and political force. "Adult" political parties often use youth radicalism to realize narrow-party political goals. The youth environment is dominated by the desire to demonstrate radical sentiments with low readiness for collective radical practices.

Young people have limited opportunities for political participation, protection, and realization of their interests, which indicates an insufficient level of democracy in Russia.

Various youth interest groups and youth movements should be able to declare their demands to the authorities legally and in an organized manner. Without the representation of specialized youth interest groups, their consistent integration in the political decision-making process is practically impossible. But in this case, they will seek to declare their demands spontaneously, radically, even in extremist forms.

The youth policy of the Russian Federation should be aimed at preventing and resolving conflicts between youth and society, and reducing the negative impact of youth radicalism.

Soon, the youth will determine the priority and direction of the country's foreign and domestic policy. That is why the apathy of young people in public and political spheres is so dangerous and destructive for Russian society.

At the same time, young people are not just the future of the country, they are the quality of this future. Therefore, the government should form a favorable atmosphere for political participation. If the work of political parties in this direction is not effective enough, then the future of the country will be in the hands of politically inept people. Consequently, it is important to find the right approach and effective methods in working with young people.

Only knowledge of their rights and obligations, and the presence of motivation will allow young citizens to see their direct impact on political life in the country.

For references, footnotes and endnotes, click here.